Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

JANUARY, 1956 TECHNOLOGY DEPT. TABLE OF CONTENTS, PAGE 55

HOT STRIP MILL

for Fairless Works, U. S. Steel Corporation

Designed and Built by MESTA

Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

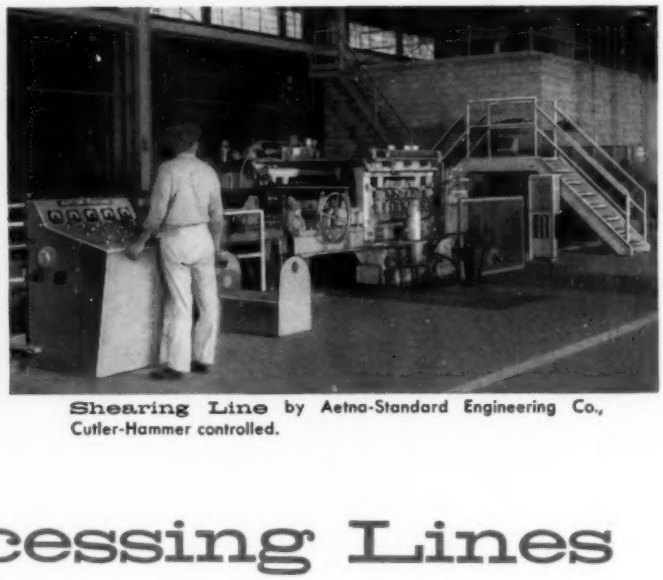
Mesta 80" Continuous Hot Strip Mill Finishing Stands

PUBLIC LIBRARY JAN 30 1956

R v. 33' Ja-Je '56

Here, at Kaiser-Fontana

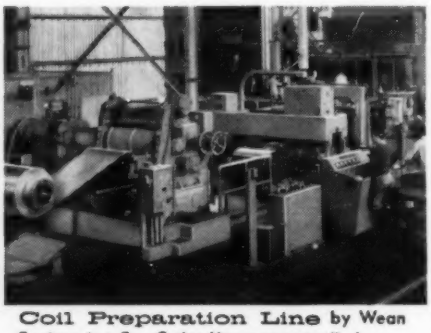
Slitting Line by Aetna-Standard Engineering Co., Cutler-Hammer controlled.



Shearing Line by Aetna-Standard Engineering Co., Cutler-Hammer controlled.

on these Processing Lines

Pickling Line by the Youngstown Foundry & Machine Co., Cutler-Hammer controlled.



Coil Preparation Line by Wean Engineering Co., Cutler-Hammer controlled.

Electrolytic Cleaning Line by Wean Engineering Co., Cutler-Hammer controlled.

It's Cutler-Hammer Adjustable Voltage Control

These installations of Cutler-Hammer Adjustable Voltage Control on processing lines in the Kaiser Steel hot strip and tinplate mills at Fontana further reveal the broad control engineering knowledge available from Cutler-Hammer to you in the solution of mill control problems of any size or type. CUTLER-HAMMER, Inc., 1269 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

CUTLER·HAMMER
MOTOR CONTROL
C·H

LOOK TO CUTLER-HAMMER MILL EXPERIENCE ... AS BROAD AS IT IS LONG

IRON AND STEEL ENGINEER; published monthly by Association of Iron and Steel Engineers, 1010 Empire Bldg., Pittsburgh, Pa. Second class mail privileges authorized at Pittsburgh, Pennsylvania, January 25, 1924.

Tech

How Dodge Manufacturing Corporation designs pillow blocks that pack more capacity in less space

THESE design features make Dodge-Timken pillow blocks ideal for use where big load capacity in small space is needed: (1) All-steel construction gives extra strength. (2) No space-consuming special thrust devices are needed, because the Timken® tapered roller bearings used take *both* radial and thrust loads in any combination. (3) Timken bearings have high load capacity because of their *full line contact* between rollers and races.

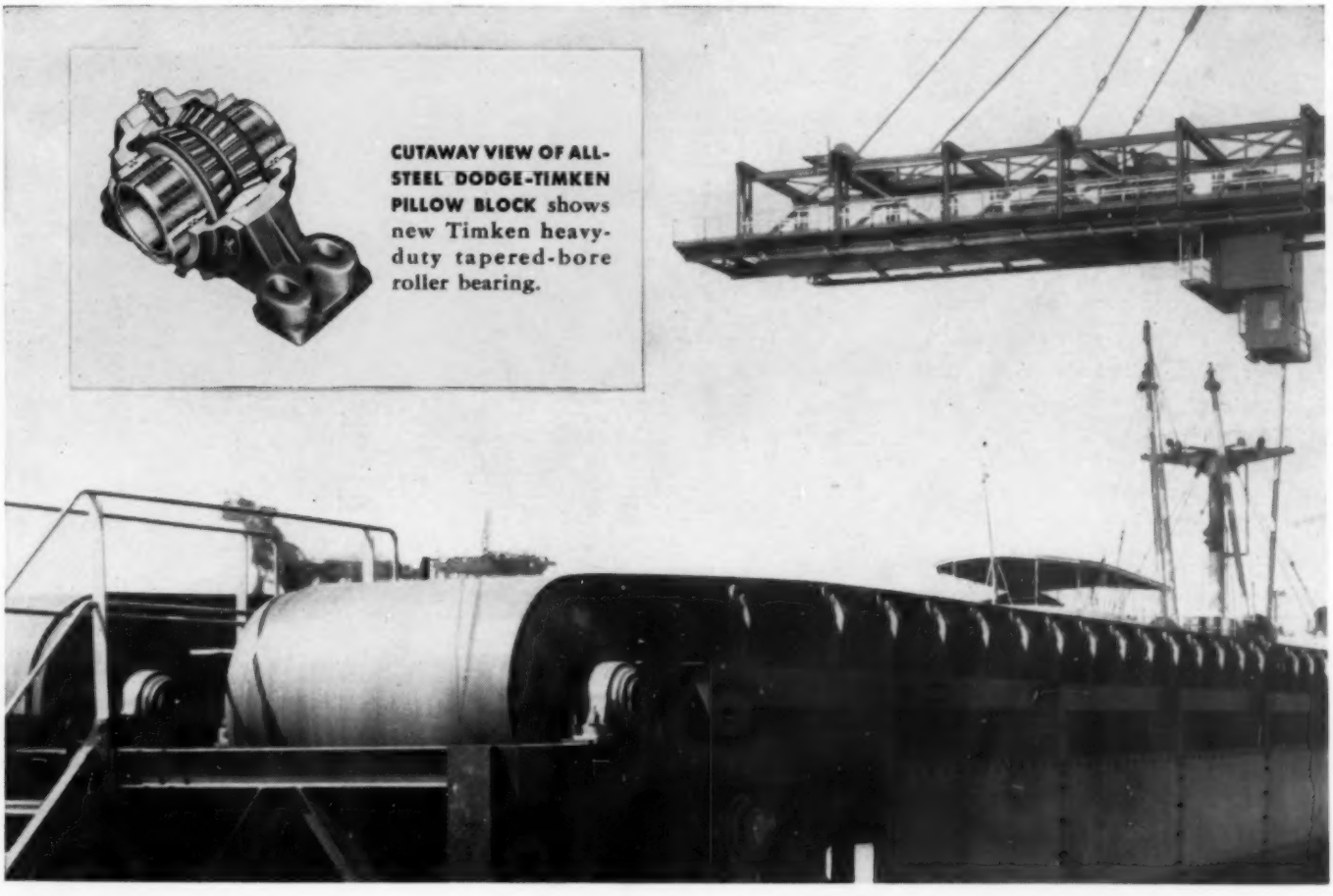
The Dodge-Timken pillow blocks shown below support all head, tail and take-up pulleys on this conveyor belt which transports ore from ships to railroad cars. Timken bearings take the shock loads because all rollers and races are made of case-carburized steel, with tough, impact-resistant cores under hard, wear-resistant surfaces.

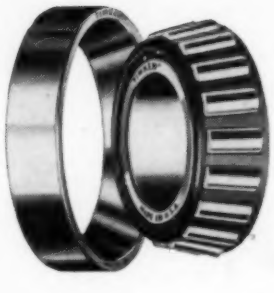
The Dodge-Timken All-Steel pillow blocks on this conveyor utilize a special new type of Timken heavy-duty, self-aligning tapered-bore roller bearing. The pillow block is one of many expansion and non-expansion types made by Dodge Manufacturing Corporation for general power transmission and machine applications; such as Type E, Double-Interlock, Type C and Special-Duty blocks. All are factory-sealed against abrasive dust and dirt.

Be sure you get all the advantages of Timken bearings when you buy or build pillow blocks, or any equipment. The Timken Company is America's only bearing manufacturer who makes its own steel. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

CUTAWAY VIEW OF ALL-STEEL DODGE-TIMKEN PILLOW BLOCK shows new Timken heavy-duty tapered-bore roller bearing.

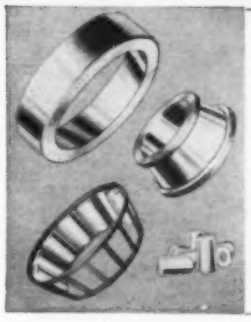




TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS



DESIGN LEADERSHIP

The first Timken tapered roller bearing was produced in 1898. Since then the one-piece multiple perforated cage, wide area contact between roller ends and ribs, and every other important tapered roller bearing improvement have been introduced by The Timken Roller Bearing Company.

Only Timken tapered roller bearings have these advantages: 1. advanced design; 2. precision manufacture; 3. rigid quality control; 4. Timken fine alloy steels.

NOT JUST A BALL ◯ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭ BEARING TAKES RADIAL ⟷ AND THRUST ⟷ LOADS OR ANY COMBINATION ✳

GENERAL ELECTRIC *Control*

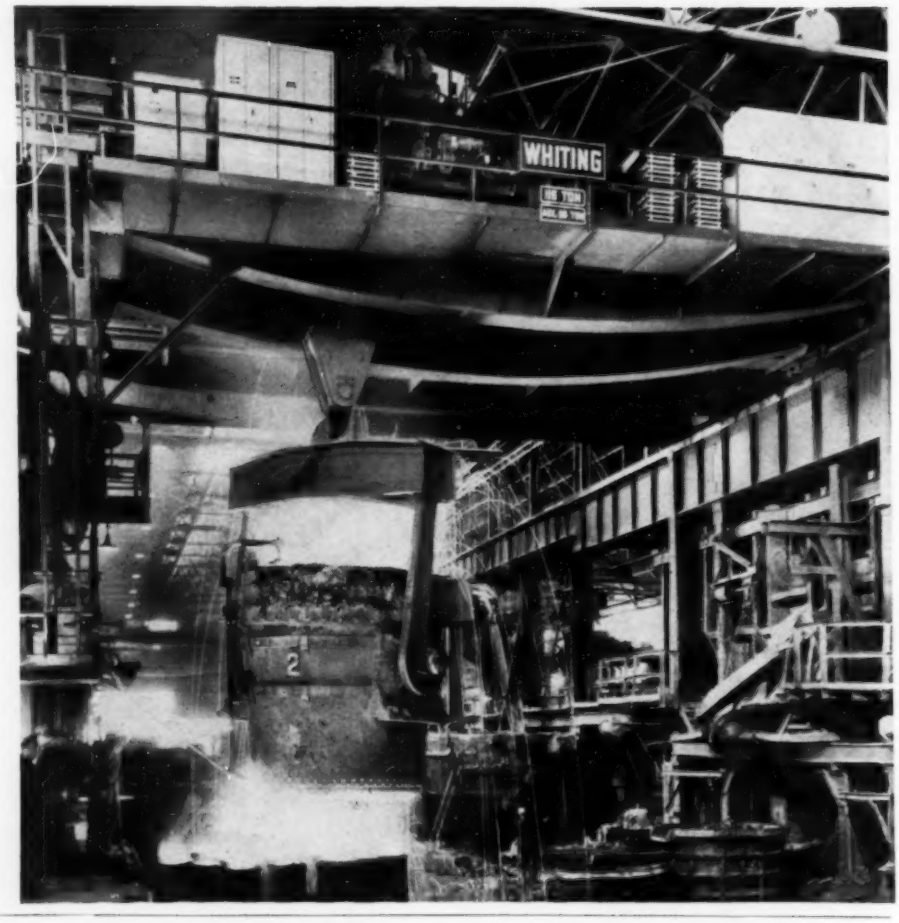
G-E Crane control is tailored to today's steel needs

A complete line of control for d-c crane applications makes it possible for General Electric to tailor systems exactly to steel mill requirements. G.E. has had over 50 years' experience in designing and manufacturing crane controls.

Minimum maintenance is required with General Electric crane control. Each component is tested under severe operating conditions and proved for the job before delivery.

Well integrated systems are assured you when one manufacturer co-ordinates the complete crane drive. General Electric engineers will help you get the most out of your crane installation by working with you or your crane manufacturer from initial design to final installation.

You can save thousands of dollars a year in materials handling costs because of the handling accuracy inherent in G-E controls. Write for Bulletin GEA-5408A (see coupon on right).



Lower maintenance, longer service with G-E Limit Switches

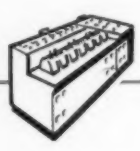
Heavy duty construction of General Electric rotating limit switches enable them to stand up under the rugged shock, vibration and dust conditions of steel mill operation.

Double-break contacts provide long life by providing two contact surfaces. Each contact is independentally adjustable for opening or closing. Insulated parts are high-quality non-conductors. There are no shunts or drum-type segments to maintain.

Wide range of gear ratios and types of enclosure give G-E limit switches great versatility. General Electric has a complete line of heavy duty track-type and rotary limit switches. Write for Bulletin GEA-5994 (see coupon on right).

* Trade-mark of General Electric Company.

G-E control for the steel industry meets AISE standards and is designed for rugged operations in steel mills. From simple resistors to complex mill drive control, General Electric Company will supply all your steel mill needs.



SPECIAL STEEL MILL CONTROLS

SYNCHRONOUS MOTOR CONTROL

LIMITAMP CONTROL

News for the steel industry

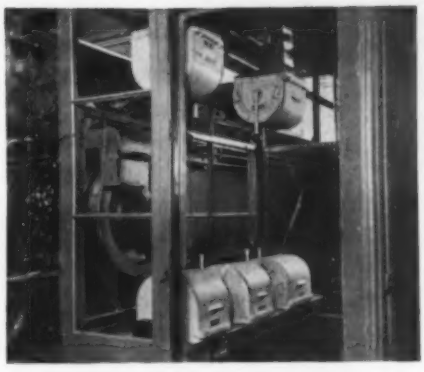
G-E Master Switches designed for tough steel applications

Available with up to 12 circuits as standard equipment, G-E master switches are specifically designed for rugged applications. Cam-operated and dustproof, they are ideally suited for steel mill drives, crane hoists, and other tough materials handling operations.

Rugged, tight-fitting, cast aluminum covers help protect operating cams and contacts against dirt, dust and damage from external blows. A wide variety of operating mechanisms are available.

All sizes of G-E master switches are actuated by cam assemblies which can be modified easily to change operating sequence. Position feel is obtained by a star-wheel and pawl arrangement which is adjustable to operator's preferences.

It is easy to remove stationary and movable contacts in a minimum of time without disturbing the switch wiring. For more information on G-E master switches call your nearest General Electric Apparatus Sales office.



Simplified Installation—low maintenance with G-E drum switches

Installation and maintenance time on General Electric's full line of drum switches has been substantially reduced by designing all working parts to be completely accessible.

Conduit boxes are provided with knockouts in the bottom, back and sides so many connections can be made.

Easily removed front covers (back covers also on larger units) provide room for wiring and for adjustments.

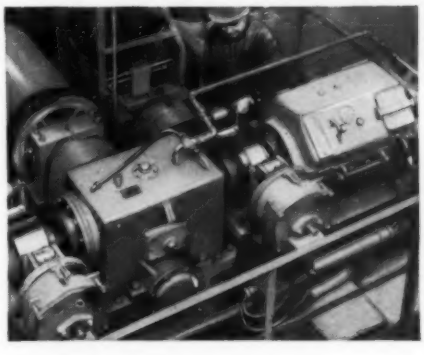
Doubled contact life is possible with G-E drum switches. Reversible finger contacts mean the elements need only be turned over when excessive wear is noted. Only one screw has to be removed to do this. Segments are easily replaceable and they can often be turned end for end to provide even longer life.

Operating mechanisms are interchangeable—standard horizontal handle for rope wheel, vertical handle, or switchboard mechanism. In addition the mechanisms may be positioned in increments of 90° for maximum flexibility. Write for Bulletin GEA-6307.

New G-E DC Brake provides excellent service at Jones & Laughlin

Jones & Laughlin Steel Corporation, one of four leading steel companies that participated in field testing G.E.'s new d-c brake, specified several more brakes for a slab handling crane on the basis of the excellent performance of the test brake.

Typical initial installations included screwdowns, billet chipper, slab depiler, manipulator crane, and coil unloader. Over 600 subsequent installations have proved the brake's performance under severe operating conditions.



General Electric Company
Apparatus Sales Division
Sec. 784-1
Schenectady 5, New York.

Please send me the following bulletins:

- ☐ GEA-5408A. DC CRANE CONTROL
- ☐ GEA-5994. LIMIT SWITCHES
- ☐ GEA-6307. DRUM SWITCHES
- ☐ GEA-6214. DC BRAKES

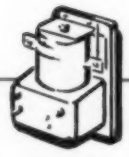
NAME.....

COMPANY.....

CITY.....STATE.....

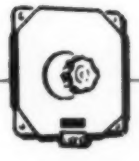
Progress Is Our Most Important Product

GENERAL ELECTRIC

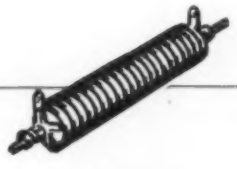


RELAYS

CONTACTORS



RHEOSTATS



RESISTORS

THRUSTOR* MECHANISMS

ANOTHER *expansion* FOR AETNA-STANDARD

● Aetna-Standard's fourth major expansion in 15 years expands production capacity by 40%.

The expansion increases machining, welding and assembly facilities with more floor space and new machine tools. A new power plant moves the KVA load from 300 to 750 KVA capacity.

The continued demand for steel, copper, brass, aluminum, rubber and plastic requires more and more production machinery, such as Aetna-Standard designs and manufactures. Capacity to produce more equipment is **a responsibility** of the machinery manufacturer who depends upon these basic industries for his orders.

AETNA•STANDARD

THE AETNA-STANDARD ENGINEERING COMPANY

GENERAL OFFICES: PITTSBURGH, PA. **PLANTS: ELLWOOD CITY, PA., WARREN, OHIO**

CONTINUOUS GALVANIZING LINES ● CONTINUOUS ELECTROLYTIC TINNING LINES ● SIDE TRIMMING AND SHEAR LINES AND OTHER FINISHING EQUIPMENT ● CONTINUOUS BUTT WELD PIPE MILLS ● SEAMLESS TUBE MILLS ● DRAWBENCHES AND OTHER COLD DRAW EQUIPMENT ● ROLLS AND CASTINGS ● EXTRUDERS, MILLS, PRESSES FOR RUBBER AND PLASTIC

BIG FACILITIES

WITH PRECISION TOOLS AND WORKMANSHIP

● This is one section of Aetna-Standard's big plant at Ellwood City, Pa. A detail would reveal big planers and small planers; turret lathes and boring mills; a toolmaker's shop and a pattern shop; a foundry and several assembly bays . . . welders, fitters, electricians and other craftsmen.

You would see all types of weldments coming from the big weld shop. You would see many machinists at work. You would see excellent facilities inside the plant for shipping by rail or truck.

To manufacture pipe and tube mills, galvanizing lines, drawbenches, shear lines and other basic production machinery, requires big facilities, precision tools and workmanship.

To meet their responsibility to customers in steel, copper, brass, aluminum, rubber and plastic, Aetna-Standard in recent months has increased its productive capacity by 40%, the fourth major expansion in 15 years.

AETNA • STANDARD

THE AETNA-STANDARD ENGINEERING COMPANY

GENERAL OFFICES: PITTSBURGH, PA. **PLANTS: ELLWOOD CITY, PA., WARREN, OHIO**

CONTINUOUS GALVANIZING LINES • CONTINUOUS ELECTROLYTIC TINNING LINES • SIDE TRIMMING AND SHEAR LINES AND OTHER FINISHING EQUIPMENT • CONTINUOUS BUTT WELD PIPE MILLS • SEAMLESS TUBE MILLS • DRAWBENCHES AND OTHER COLD DRAW EQUIPMENT • ROLLS AND CASTINGS • EXTRUDERS, MILLS, PRESSES FOR RUBBER AND PLASTIC

NATIONAL CARBON BRUSHES ARE

BEST FOR MAIN DRIVE MOTORS AND GENERATORS

Best Because:

- "National" Brushes provide maximum commutator stability.
- "National" Brush grades are specifically designed for machine-operating characteristics.

Use These Grades:

to meet all service requirements.

- **N—4**
- **SA—45**
- **SA—35**

Here's Why:

"National" Brushes meet the widest variations in the following operating conditions.

- Current densities
- Commutator surface speeds
- Atmospheric contamination

Always consult your National Carbon Representative when selecting brushes. He is there to serve you with the best and most complete line of brushes for mill and mine operations.

The term "National", the Three Pyramids Device and the Silver Colored Cable Strand are registered trade-marks of Union Carbide and Carbon Corporation

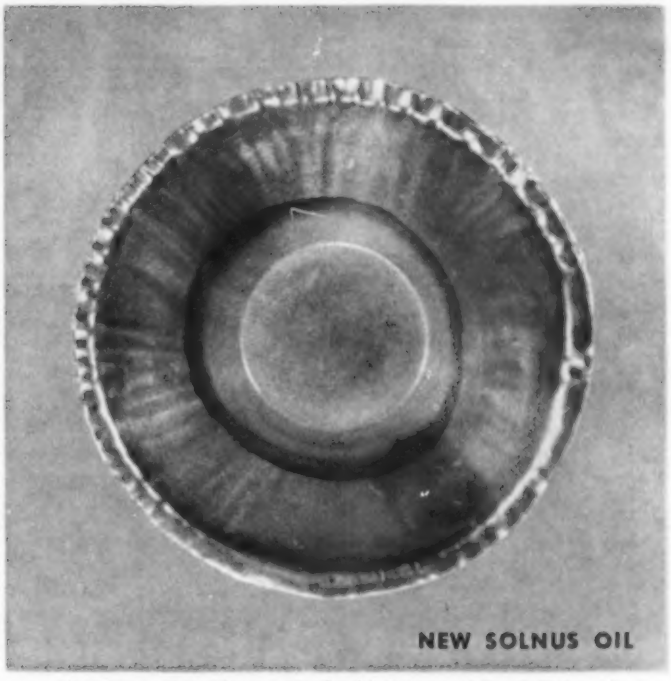
NATIONAL CARBON COMPANY

A Division of Union Carbide and Carbon Corporation • 30 East 42nd St., New York 17, N.Y.

Sales Offices: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco

IN CANADA: Union Carbide Canada Limited, Toronto

To demonstrate the comparative deposit-forming tendencies of compressor oils, two drops of a typical compressor oil were heated until evaporated. Notice the large deposit, *most of which is carbon*, left by the typical compressor oil. A new Solnus oil, after the same evaporation test, leaves a much smaller deposit.



NEW SOLNUS OILS HELP KEEP COMPRESSORS CARBON-FREE

THREE MINUTE TEST right at your desk shows why Solnus oils are the best for your compressors.

The chief enemy of air compressors is carbon build-up. The best way to avoid this hazard is to use the compressor oil that has the lowest carbon-forming tendency.

Sun's new Solnus oils have been proved to be ideal compressor lubricants. The minute amounts of carbon that form are fluffy and blow away easily . . . assurance against dangerous build-up of carbon on valves and exhaust ports. Tear-downs for cleaning are kept to a minimum.

We'd like to show you, right on your desk top, the dramatic test pictured above. Ask your Sun representative about it the next time he calls or write SUN OIL COMPANY, Philadelphia 3, Pa., Dept. SI.

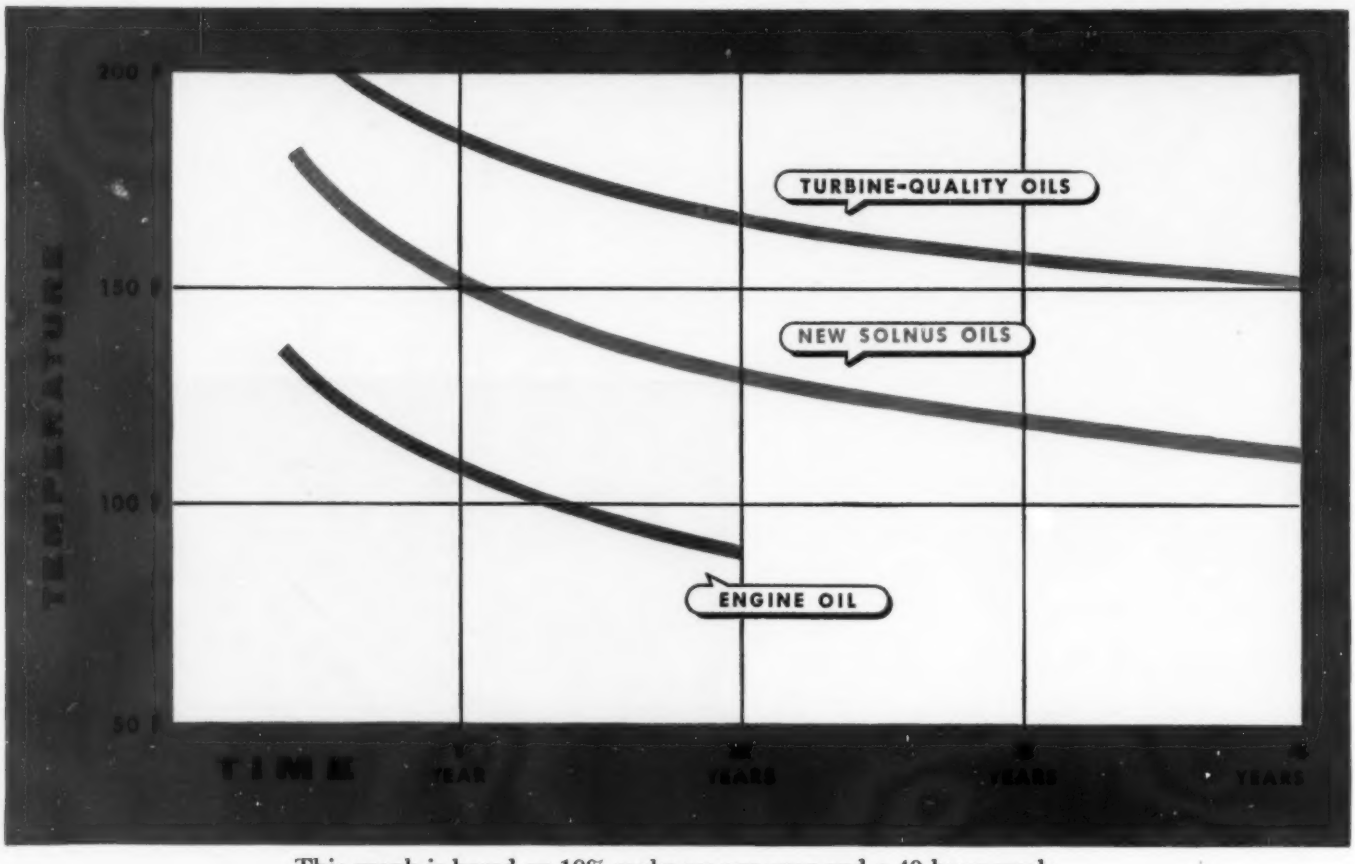
Please turn to the next page

SUNOCO

INDUSTRIAL PRODUCTS DEPARTMENT

SUN OIL COMPANY PHILADELPHIA 3, PA.

IN CANADA: SUN OIL COMPANY, LTD., TORONTO AND MONTREAL



This graph is based on 10% make-up per year and a 40-hour week.
The yellow area represents approximately 80% of all applications.

NEW SOLNUS OILS IDEAL LUBRICANTS FOR 80% OF ALL APPLICATIONS

High grade lubricants for squirt-can prices . . . New Solnus oils give more lubrication per dollar

The lubricated parts of most machines—our estimate is 80%—operate at temperatures below 130 F and the time between oil changes is less than 2 years. New Solnus oils were specifically developed to meet these operating conditions at the lowest possible cost.

The above graph compares the service life of new Solnus oils with that of an expensive, turbine-quality oil, and an oil of the type old-timers call "engine oil". The service life of the turbine-quality oil is excellent and probably covers 99% of all applications . . . but for a premium price! The engine oil has a very limited life. It cannot be used safely, except for a very short time, at even moderately high operating temperatures, and it gives very little protection against rust and corrosion.

Now look at the service life of new Solnus oils. They easily meet the service requirements of at least 80% of all oil lubrication jobs and they sell for a squirt-can price! In addition, new Solnus oils are fortified to prevent both rust and oxidation . . . a feature usually found only in more expensive oils.

For the full story on new Solnus oils, see your Sun representative or write Sun Oil Company, Philadelphia 3, Pa., Dept. SI.

SUNOCO

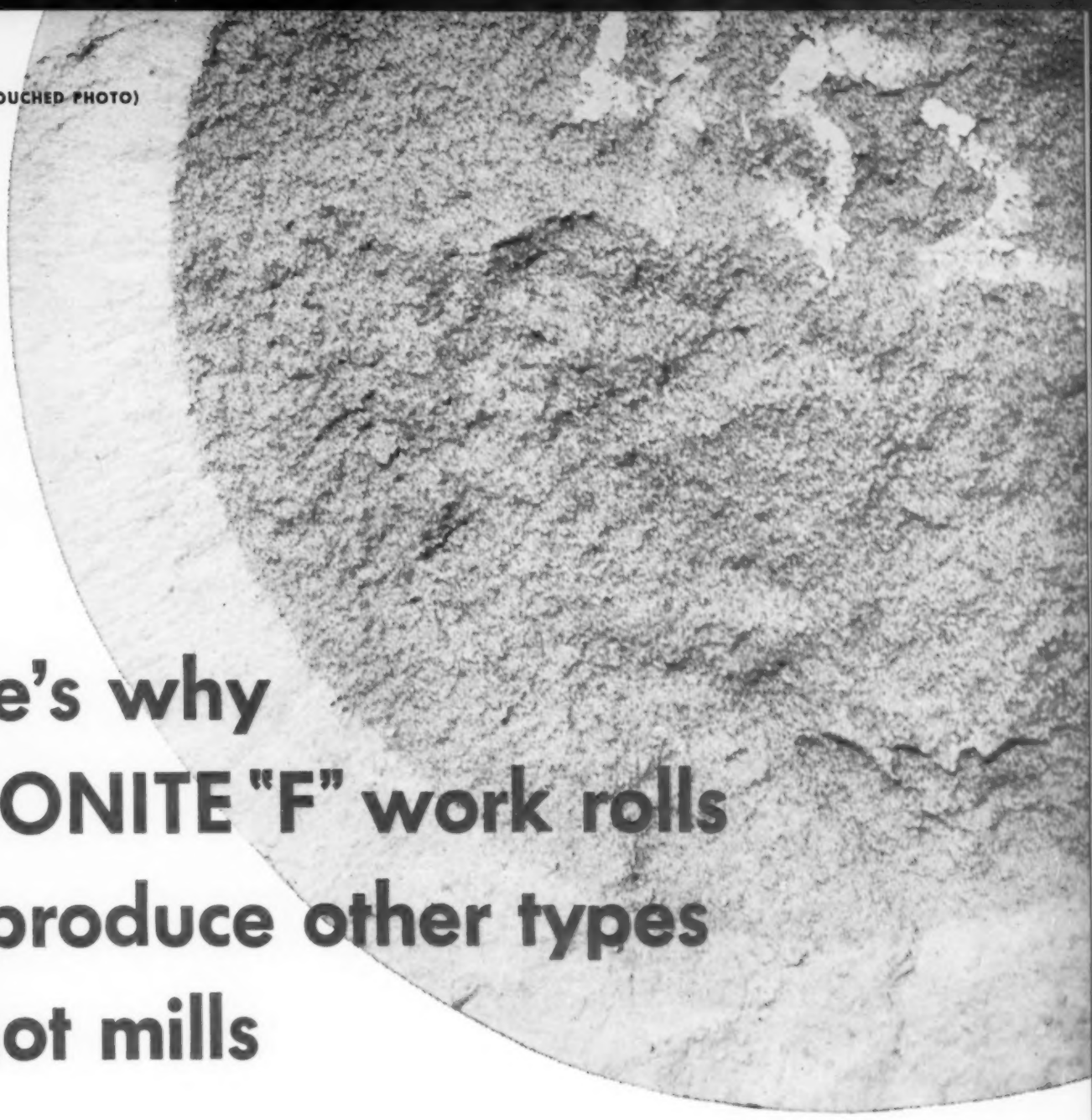
INDUSTRIAL PRODUCTS DEPARTMENT

SUN OIL COMPANY

PHILADELPHIA 3, PA.

In Canada: Sun Oil Company, Ltd., Toronto and Montreal

(ACTUAL UNRETOUCHED PHOTO)



Here's why NIRONITE "F" work rolls outproduce other types in hot mills

Take a look at the close grain structure and deep shell of this test-fractured 21" diameter Mack-Hemp Nironite "F" work roll. You can actually *see* why Nironite "F" rolls give you greater tonnages between regrinds . . . why they offer greater resistance to banding... why they last all the way to worn-out diameter. So distinctive is this close grain structure that mill operators report that they can recognize Nironite "F" rolls by the continued good roll surface even after long use—whether or not they have seen the stripes on the wabblers.

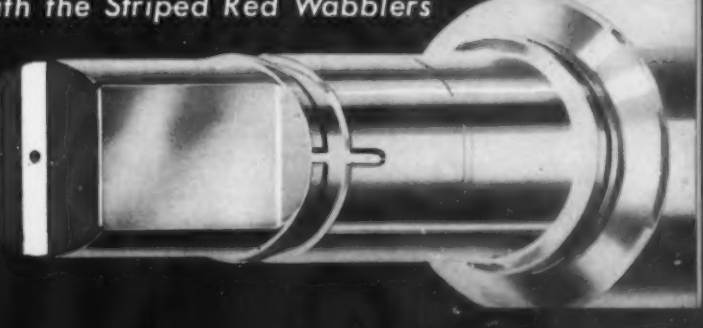
Nironite "F" rolls are high-nickel, high-chromium alloy grain type, double poured for maximum strength. They can be supplied in any desired hardness from 65 to 85 Shore scleroscope (C Scale).

Mack-Hemp offers an entire series of Nironite nickel-chromium cast iron alloys for 2-high or 4-high hot mill roughing, intermediate and finishing rolls. Your Mack-Hemp sales engineer will be glad to give you assistance in choosing exactly the right type and hardness for your particular rolling problem.

MACKINTOSH-HEMPHILL
DIVISION OF
E. W. BLISS COMPANY
Pittsburgh and Midland, Pa.

cast mill rolls • Johnston cinder pots
rotary tube straighteners
heavy-duty lathes • end-thrust bearings
steel and special alloy castings

You get more tonnage from the rolls with the Striped Red Wabblers



big industry, small world

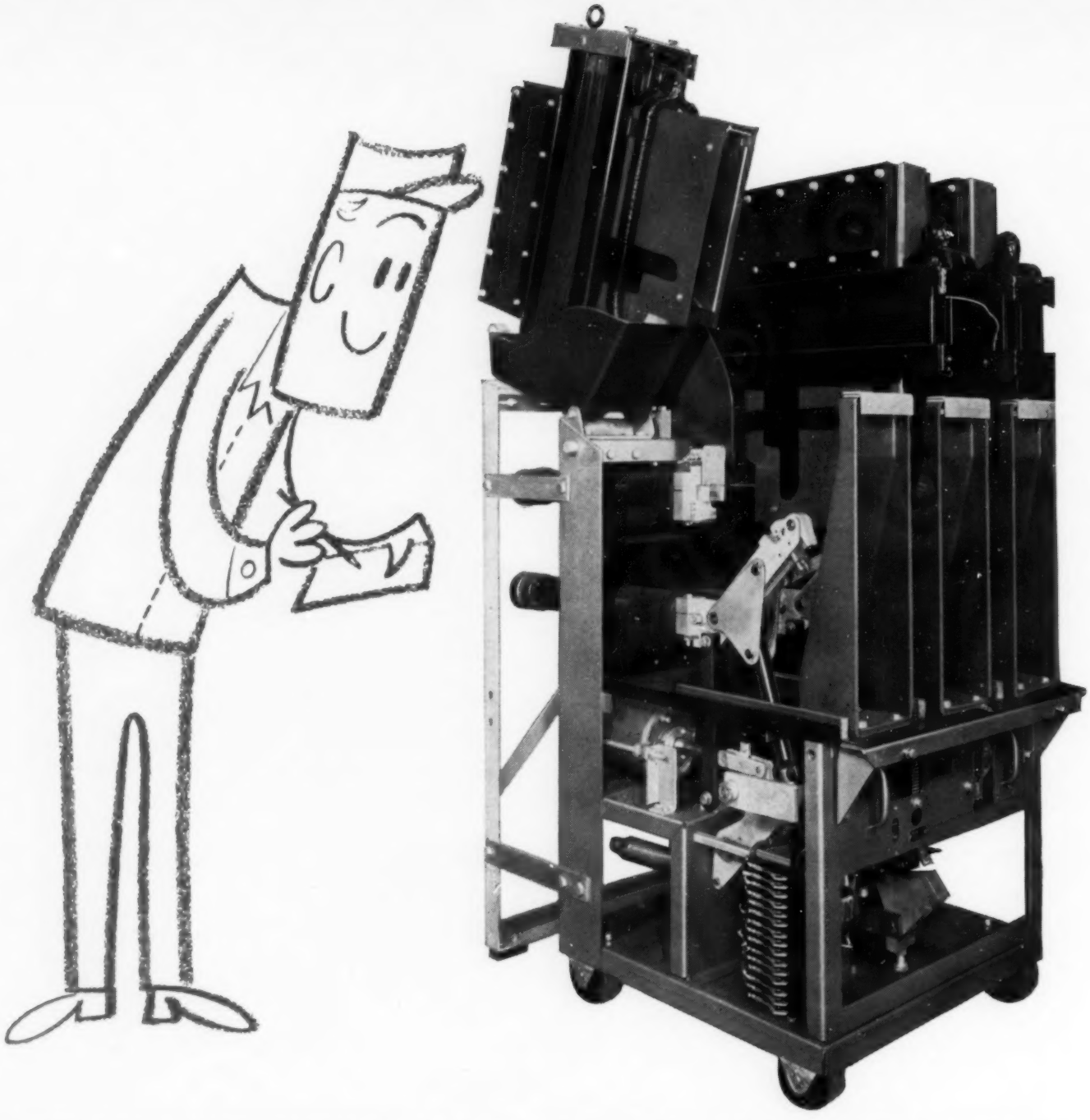
annealing covers
billet reheating furnaces, continuous
carbon restoration and annealing furnaces, continuous
controlled atmosphere generators
high-speed stress relieving furnaces
one-way fired soaking pits
pit-type annealing furnaces
slab and billet heaters, continuous
strip annealing furnaces, continuous
strip galvanizing lines, continuous
wire patenting furnaces, continuous

Wherever this steel goes – from first soak to final shipping dock – it will find that the big steel industry is a small world as far as 'Surface' equipment is concerned. Somewhere along the line, whatever its destined shape, the steel will be made more workable and more useful in 'Surface' furnaces.

Why is it so easy to bump into 'Surface' in steel mills? One reason is that 'Surface' has literally grown up with the steel industry. A better reason is the confidence that steelmakers have in the performance of furnaces and generators manufactured by Surface Combustion Corp., Toledo 1, Ohio.

Surface
STEEL MILL FURNACES

British Furnaces, Ltd., Chesterfield; Stein & Atkinson, Ltd., London
Stein & Roubaix, Paris, Leige, and Genoa; Chugai Ro Kogyo Kaisha, Ltd., Osaka
Benno Schilde Maschinenbau, A.G., Bad Hersfeld (Hessen, Germany)



SEE VALUE HERE YOU'LL SEE NOWHERE ELSE

Operating engineers in the electrical industry often say you can see the higher quality in I-T-E switchgear even when you stand 'way back.

Of course, they're only partly right. You can easily see the practical component arrangement, the all-welded steel construction with compartments designed to retain shape even when lifted as a unit, and the clean, neat appearance. These are standard on all I-T-E switchgear.

But we want you to look closer—see even more. For example, in Metal-Clad Switchgear: the easy-to-service horizontal drawout design; the tilting arc chutes; the extra-heavy insulation. There's quality in every detail—quality that means dollars' more value for your switchgear investment and years' longer troublefree service.

Why not phone the I-T-E office nearest you. Or write for bulletin 7004 giving a complete description of 5, 7.5 and 15 kv switchgear. I-T-E Circuit Breaker Co., 19th & Hamilton Sts., Phila. 30, Pa.

I-T-E

I-T-E CIRCUIT BREAKER COMPANY · Switchgear Division

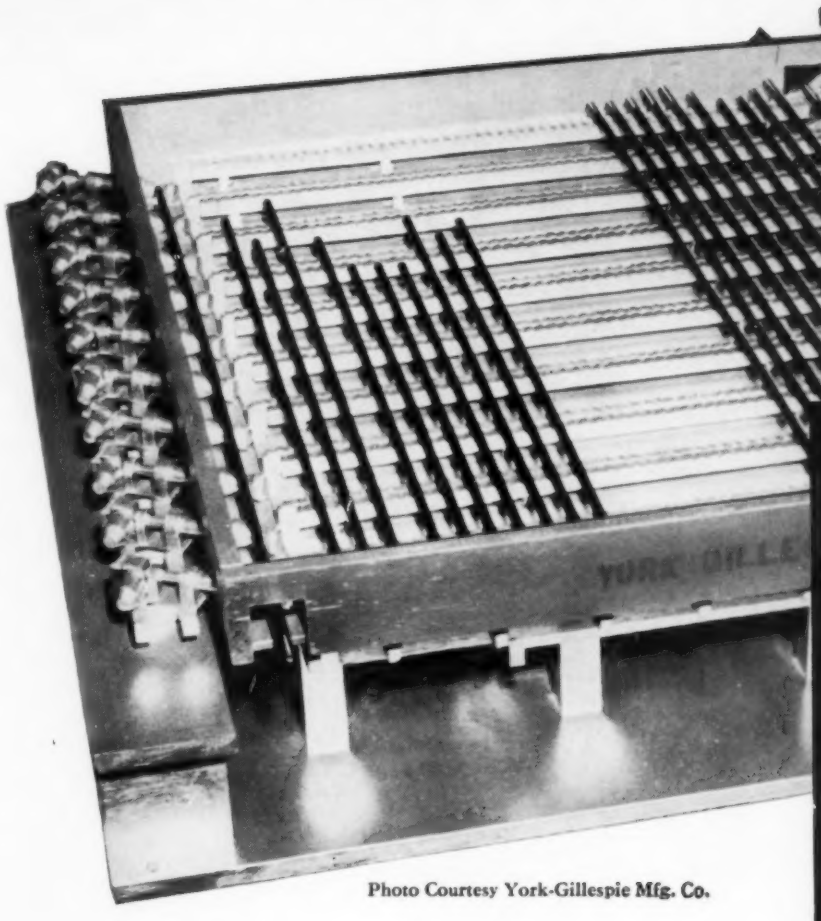


Photo Courtesy York-Gillespie Mfg. Co.

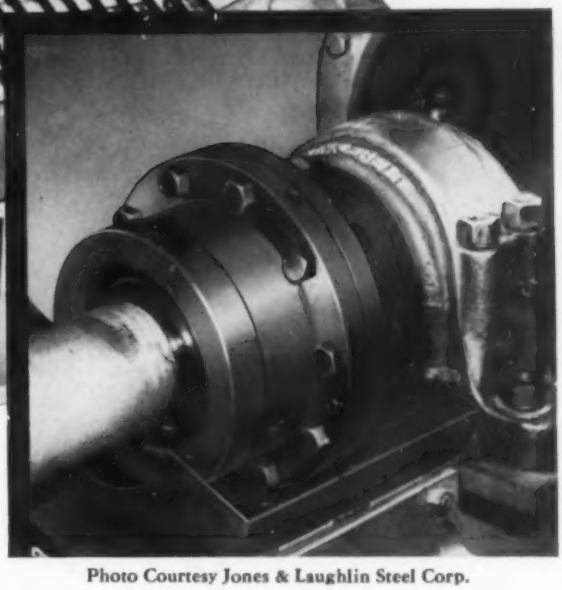


Photo Courtesy Jones & Laughlin Steel Corp.

Fast's Couplings help roll 30 tons of steel per hour through new Jones & Laughlin normalizing and quench tempering furnaces

At the Jones & Laughlin Aliquippa Works, Fast's Couplings are part of a new materials-handling process for transferring tubular steel products through the continuous normalizing and quench tempering furnaces. Pipe tubing is rotated automatically by a series of specially designed racks as it is transferred through the furnace. This design eliminates chill spots and minimizes warpage, insuring uniform heating at capacities up to 60,000 pounds per hour.

Fast's Couplings were used exclusively in this equipment . . . and for good reasons: They are subject to operation at extremely high temperatures that demand Fast's all-steel construction; torque transmission is high (low 3 RPM speed at eccentrics); Fast's Couplings offer mis-alignment protection for long-distance shafting—particularly important because of high temperatures and subsequent shaft growth; and Fast's Couplings are the best "shut down insurance" where continuous, trouble-free operation is essential.

This is another example of how Fast's Couplings fill specialized needs of industry with their famous Fast's construction and performance features. Koppers free engineering can assist you in selecting the right Fast's Coupling for your needs also. Mail the coupon below for a free catalog to: KOPPERS COMPANY, INC., Fast's Coupling Dept., 211 Scott St., Baltimore 3, Maryland.

THE ORIGINAL **Fast's Couplings**

KOPPERS

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE, MD. This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Koppers Electrostatic Precipitators, Aeromaster Fans and Gas Apparatus. ***Engineered* Products Sold with *Service***

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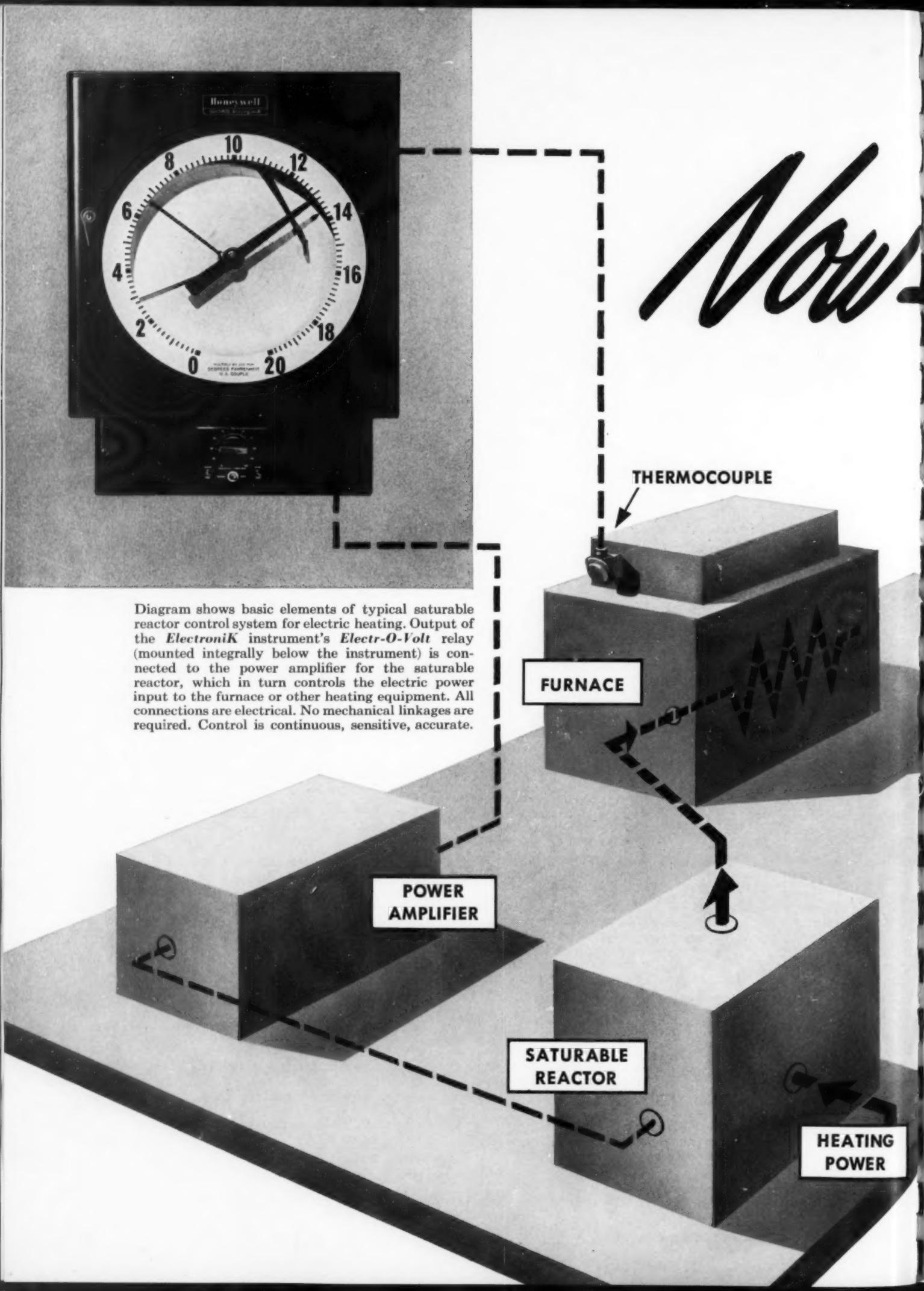

Diagram shows basic elements of typical saturable reactor control system for electric heating. Output of the *ElectroniK* instrument's *Electr-O-Volt* relay (mounted integrally below the instrument) is connected to the power amplifier for the saturable reactor, which in turn controls the electric power input to the furnace or other heating equipment. All connections are electrical. No mechanical linkages are required. Control is continuous, sensitive, accurate.

continuous, accurate control of electrically heated equipment

ElectroniK instrumentation with Electr-O-Volt* relay provides continuous throttling in saturable reactor control systems

You can now regulate temperatures of electrically heated furnaces, ovens, and similar processing equipment within exceptionally close tolerances, by using an advanced *ElectroniK* control system in conjunction with saturable reactors. This type of control eliminates the abrupt surges of power and the expense of contact replacement which are frequently objectionable factors of on-off or pulsed electric control.

Continuous control action. The *Electr-O-Volt* relay, actuated by the *ElectroniK* instrument, provides continuously variable control input to the saturable reactor power amplifier. This arrangement gives true proportional-plus-reset control action, which adjusts heat input to compensate for size of load, ambient temperature and other transient and long-term variations in heat demand.

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Broad range of use. *ElectroniK* control for saturable reactors is applicable to high-temperature heat-treating furnaces, reaction vessels and many other types of electrically heated equipment. It makes possible smooth, finely-adjusted regulation of electric power at high efficiency.

For a discussion of how this control can be applied to your specific problems, call your local Honeywell sales engineer. He's as near as your phone.

Minneapolis-Honeywell Regulator Co., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario. *Trademark

● **REFERENCE DATA:** Write for Catalog 1531, "*ElectroniK* Controllers," and for new Bulletin 8420, "*Electr-O-Volt* Relay."

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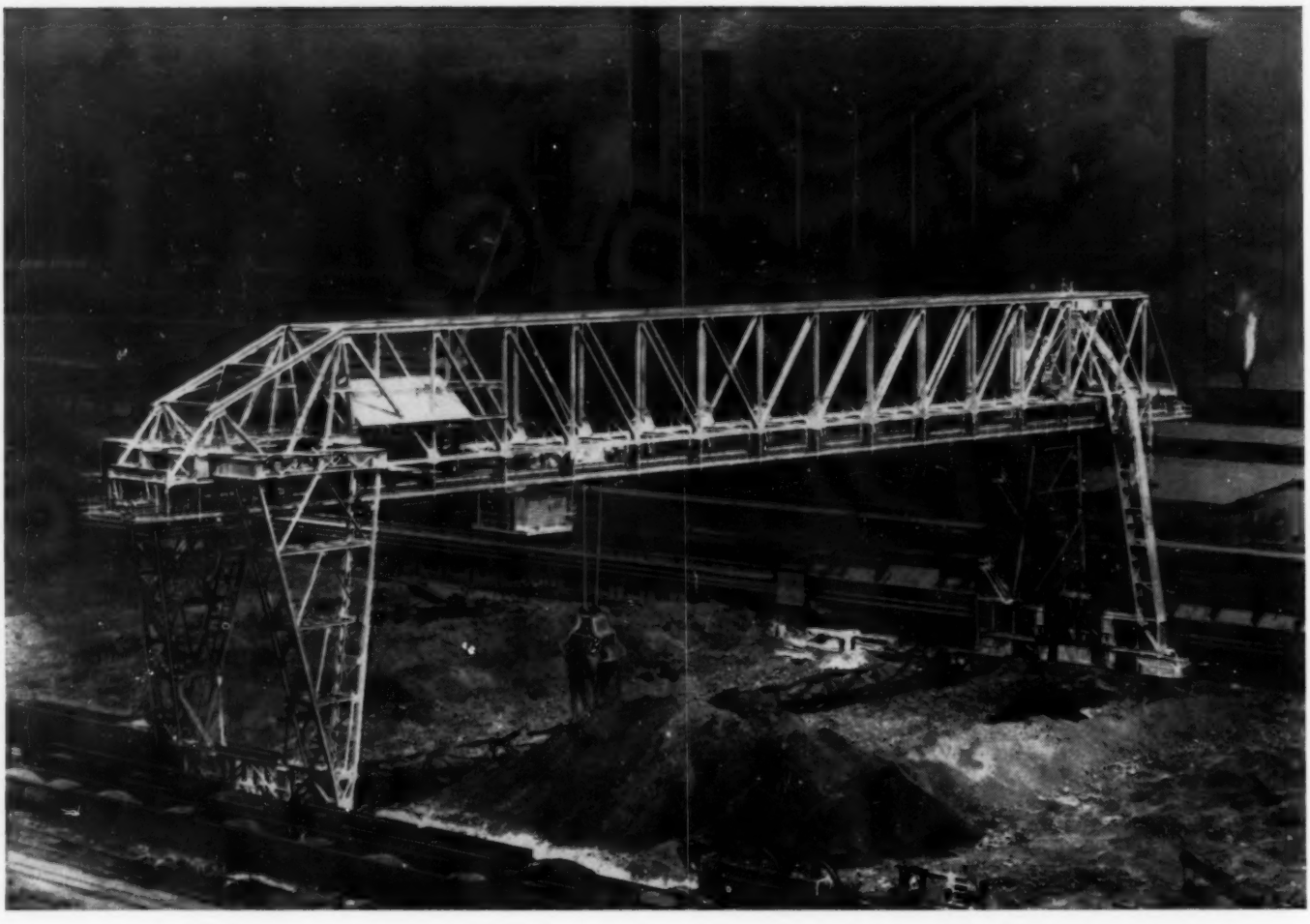
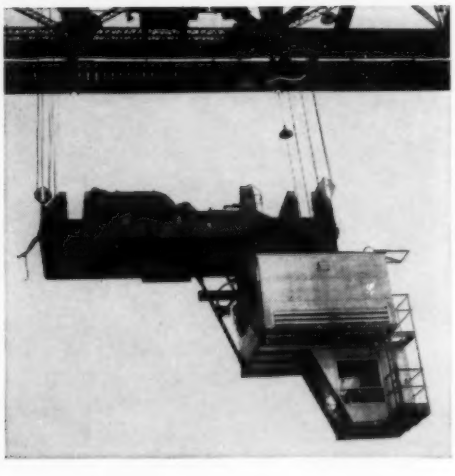


you CAN double ore bridge capacity without production shutdowns!



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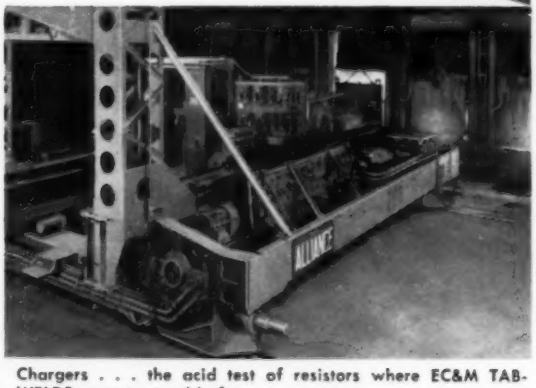

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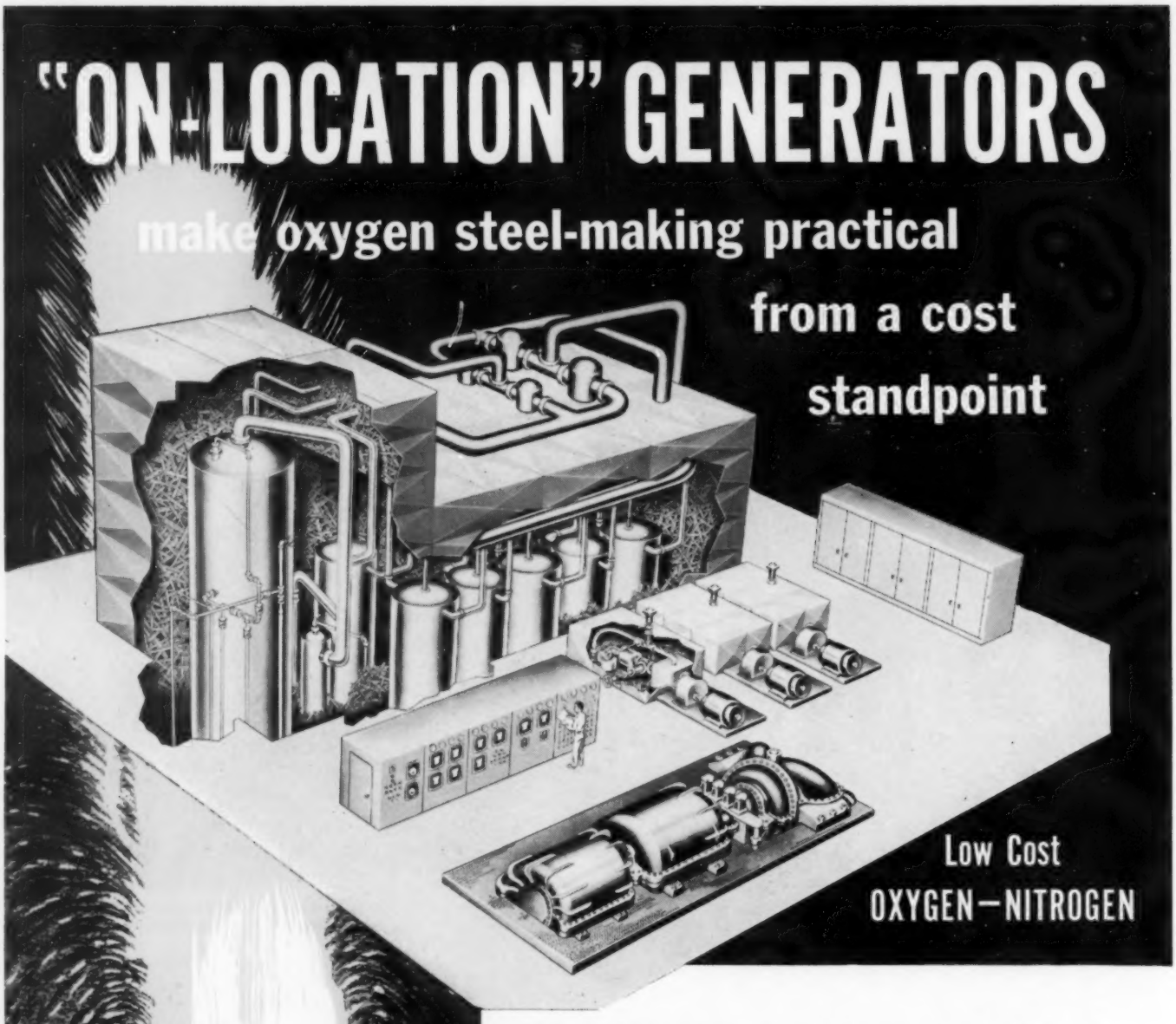

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Patent Reviews

By MELVIN NORD
Patent Attorney
Detroit, Mich.

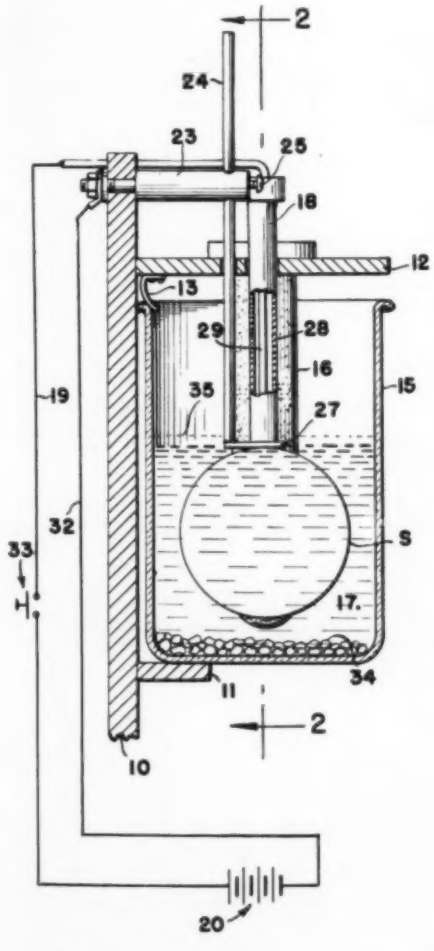
. . . . copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents each . . . . patents reviewed cover period August 30, 1955 through September 13, 1955 . . . .

DETERMINATION OF TIN ON TINPLATE

▲ U.S. 2,716,596, issued August 30, 1955 to Delbert P. Robertson and assigned to National Steel Corp., discloses a new method of determining the amount of tin on tinplate. The inventor first discusses the disadvantages of the known methods, and points out errors in them.

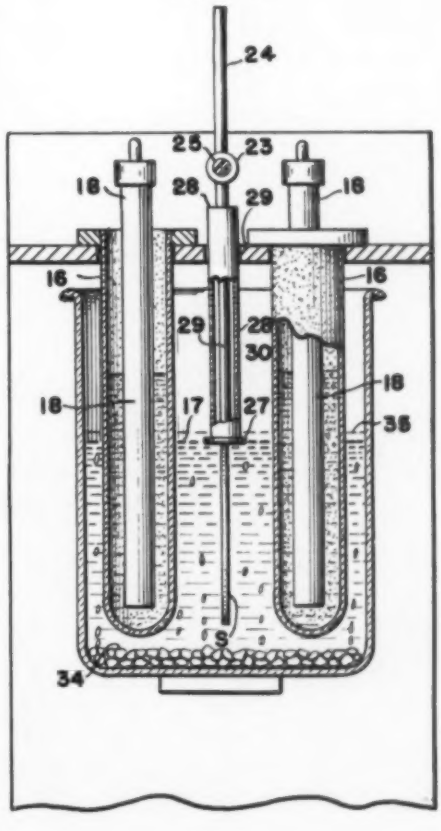
The new method is based on electrolytic stripping from the sample in aqueous hydrochloric acid, followed by titration to determine the amount of tin. This apparatus is shown in Figures 1 and 2.

Figure 1



In carrying out the process, about 200 milliliters of 1 to 7 hydrochloric acid solution is placed in a 300 milliliter beaker 15, the sample of tinplate is suspended by means of the magnet 30 from the support or foot 27 and the beaker is placed in position on shelf 11, so as to completely immerse the sample S in the body of solution 17. About 7 grams of marble chips are placed in the beaker shown at 34 before it is placed on the shelf, and the marble chips through their reaction with the hydrochloric acid, slowly generate carbon dioxide which bubbles up through the solution and forms a blanket 35 of carbon dioxide directly above the upper surface of the body of solution. Additional hydrochloric acid stripping solution is poured into cups 16 to raise the level of the catholyte above the anolyte. The switch 33 is closed and a current of 2 amperes at a potential of 7.5 volts is allowed to flow until all of the tin is in the solution. This may require from 1 to 5 minutes, depending upon the coating weight of tin on the sample. During this time, catholyte which is substantially free of dissolved tin flows into the anolyte to prevent the plating of tin onto the cathode 18 by preventing the migration of ions of dissolved tin from the anolyte through the porous cups into the catholyte. The time is not critical and the period only needs to be long enough so that all of the tin is removed from the sample. Continuing the flow of current after the tin has been removed does not seriously affect the results.

Figure 2



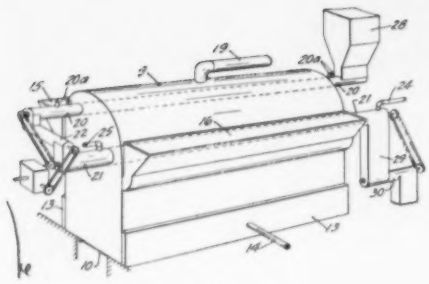


Figure 3

After all of the tin has been removed from the sample, the beaker is removed from the shelf 11 and a small amount of starch indicator is added to the bath 17. Then the solution is titrated with the standard potassium iodate solution to a blue end point. As the amount of iodine required to react with the tin is known, the amount of tin present on the sample can be readily calculated.

CONCENTRATING LOW GRADE ORES

U.S. 2,717,205, issued September 6, 1955 to Enoch F. Edwards and assigned to Be Vant Mining & Refining Corp., describes a method for concentrating and agglomerating low grade nonmagnetic ores into a condition suitable for smelting.

The steps in the process are as follows: heating and drying pulverized nonmagnetic low grade ore, delivering the preheated nonmagnetic ore to a reducing and magnetizing conveyor mechanism, passing reducing gas through the conveyor mechanism, cooling the reduced ore, separating the magnetized ore to produce concentrates, drying the ore concentrates, and sintering the dried concentrates.

The apparatus is shown in Figures 3, 4, 5. Pulverized low grade nonmagnetic ore is introduced into a hopper 28 which delivers it to the upper heating and drying conveyor 20. This conveyor carries the ore through the upper portion of the furnace where it is heated and a large percentage of the moisture is driven off through vapor outlets 20a. The preheated ore is then carried to the reducing conveyor by conveyor 22 and is thoroughly agitated by the windows in the spiral 21a as the reducing gas is passed through the conveyor tube from inlet 24 to outlet 25. The conveyor 22 is airtight and forms in effect an air lock to maintain a reducing atmosphere around the heated ore. From the conveyor 21, the magnetized ore is delivered to a hopper 29 and from there is delivered to a magnetic separation unit after being cooled in a quenching chamber. After it has been magnetically separated, the concentrates are discharged to a drying area and are transferred to the sintering chamber S through the chute 16. Peat is introduced through chute 16. Oxygen is supplied for the sintering operation through passages 12 and when the charge has been completely sintered the trap door 10 is opened and the sinters are dropped out of the chamber S and a new charge is introduced. The gases produced by the sintering operation not only heat the conveyors 20 and 21 and the ore being carried but are carried by pipe 19 to a CO_2 absorption unit and are then carried to the inlet 24 for introduction into the conveyor 21. The chemical reactions which take place during the reduction of the nonmagnetic ore to magnetic ore by the reducing gases containing large percentages of H_2 and CO is as follows:

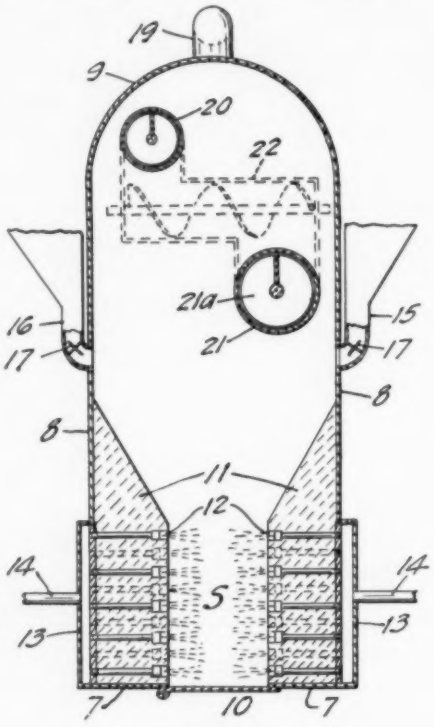


Figure 4

$$CO + 3Fe_2O_3 \longrightarrow CO_2 + 2Fe_3O_4$$

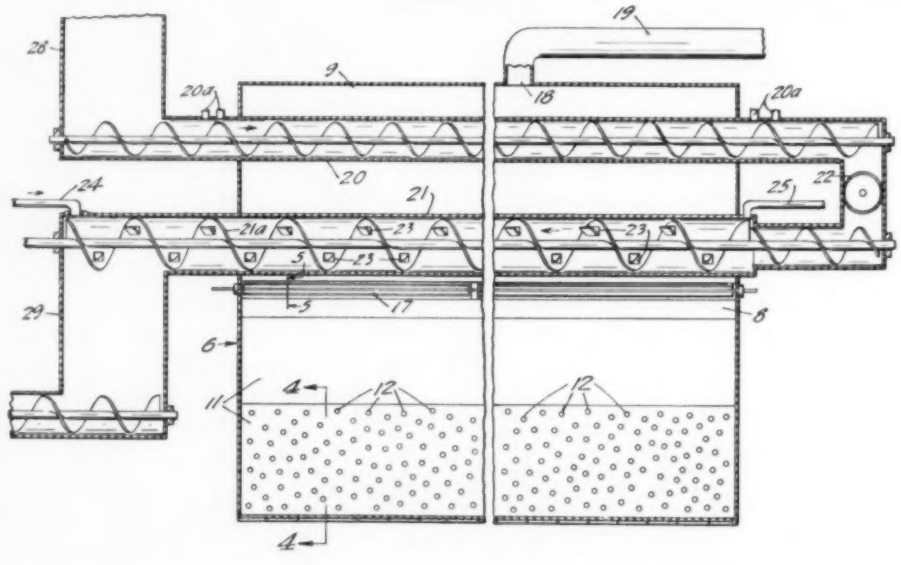
$$H_2 + 3FeO_3 \longrightarrow H_2O + 2Fe_3O_4$$

LOW-TEMPERATURE REDUCTION OF IRON OXIDE IN THE PRESENCE OF A HALIDE

U.S. 2,716,601, issued August 30, 1955 to Henry L. Crowley and assigned to Republic Steel Corp., describes a process for producing nonpyrophoric powdered iron by the low temperature reduction of iron oxide-containing materials. One advantage claimed is that the product has increased magnetic quality.

As an example of the method: synthetic ferric oxide, substantially pure, was spread one to two inches deep upon trays in a hydrogen-tight stationary retort furnace. After heating this material to 550 C, the atmosphere of the furnace having previously been purged of oxygen-contained gas, hydrogen containing 2 to 3 per cent HCl was supplied to the furnace at a rate such that a stoichiometric amount of the hydrogen would pass through the furnace within a four-hour period.

Figure 5



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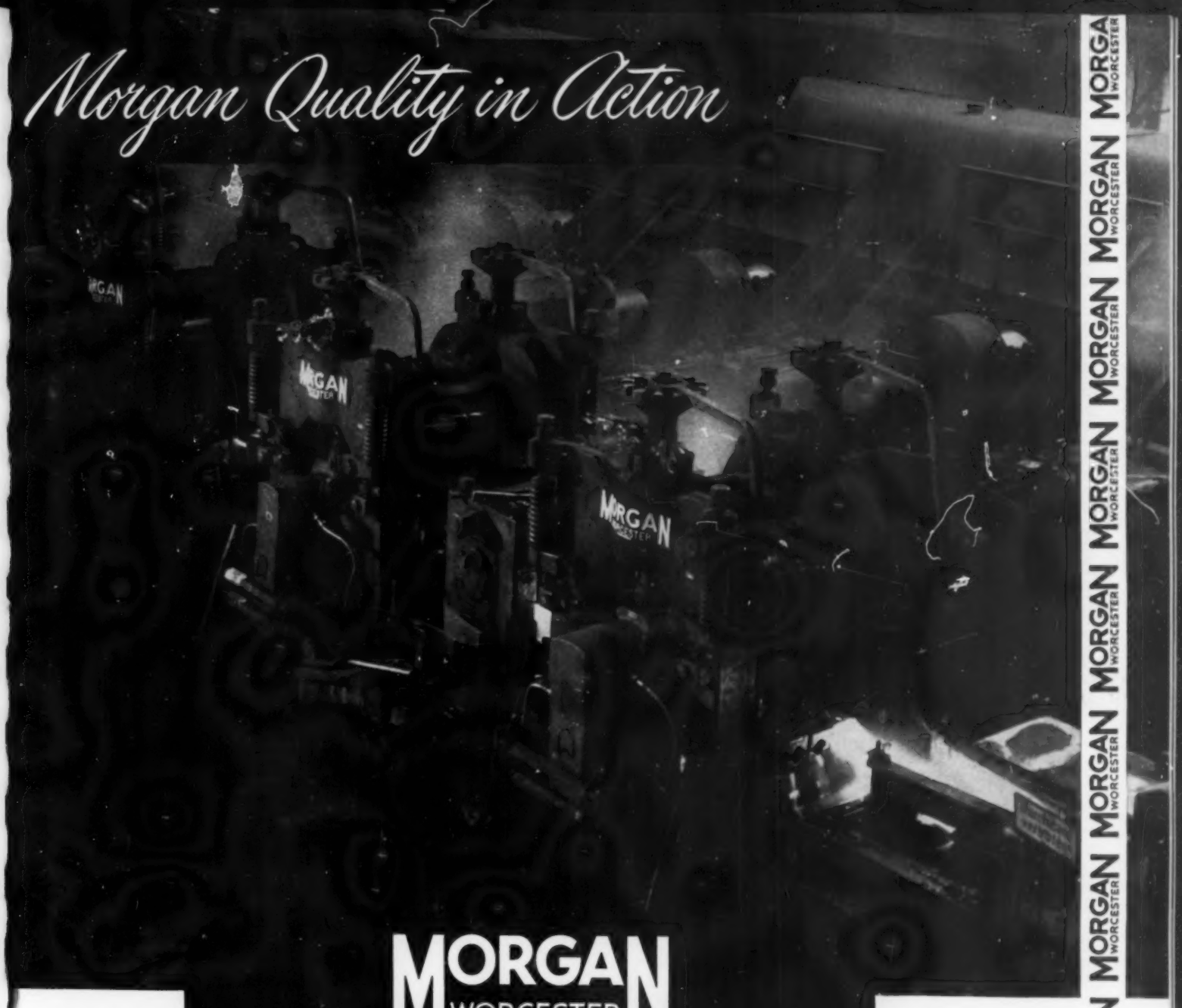

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33

At the expiration of this time, the HCl feed was stopped and pure oxygen-free hydrogen was passed through the furnace at the same rate for another period of about one-half hour to one hour. This was for the purpose of sweeping out any remaining HCl and reducing to the elemental form any iron in the form of iron chloride remaining at the end of the principal reducing period. The furnace was then sealed against influx of air and cooled to a temperature such that the iron as removed would not immediately recombine with oxygen, i.e. below about 150 F. The product so made was found to be non-pyrophoric and to have magnetic properties superior to iron produced from the same oxide by simple hydrogen reduction at a substantially higher temperature.

According to the inventor, the presence of hydrogen halide is necessary in order that the product be non-pyrophoric.

COLD DRAWING OF STAINLESS STEEL

In the cold drawing of ordinary low carbon steel, the steel is pickled, and upon removal from the pickling vat, is allowed to dry. The drying of the pickling solution on the surface of the steel leaves a light deposit of rust which is very beneficial as a lubricant in the subsequent drawing of the steel through a die.

In the drawing of stainless steel, however, the steel is resistant to the action of pickling solutions, and a coating may not therefore be formed on the surface of stainless steel by pickling. When attempts are made to draw the stainless steel, it merely sticks or galls in the die. This is especially true in the drawing of tubing over a mandrel where the metal is being worked on both the inner surface of the tube and the outer surface. Many attempts have been made to find a satisfactory drawing lubricant, but materials developed for this purpose have been generally unsatisfactory. Consequently the present method of cold drawing stainless steel involves the coating of the steel with a film of lead. The lead coated stainless steel rod or tube is then drawn and after completion of the drawing operation, as well as for each intermediate annealing operation, the lead is removed by nitric acid, which acid reacts with the lead, but does not attack the stainless steel. This is quite an expensive operation, as well as a relatively slow one. Moreover, it is difficult to apply the lead to secure a uniform thickness of coating and any variation in the thickness of the lead film reflects itself in the surface of the stainless steel tube. Furthermore, the amount of reduction in each drawing pass must be substantially less than the reduction which can be taken in each pass in the cold drawing of low carbon steel.

In U.S. 2,717,221, issued September 6, 1955 to Robert M. Christner, a lubricant or drawing compound is provided, eliminating the need for lead coating and permitting operation with less intermediate annealing than now required.

Lime water and iron sulphate solution are mixed together, precipitating iron hydroxide and calcium sulphate to form a heavy suspension or slurry. The reaction is as follows:

$$Ca(OH)_2 + FeSO_4 \longrightarrow CaSO_4 + Fe(OH)_2$$

The product is then dried and put into the lubricant box of a drawing bench, or else is applied as a slurry to the surface of the stainless steel and then air dried.

SURFACE HARDENING OF FERROUS METALS

U.S. 2,717,846, issued September 13, 1955 to Richard F. Harvey, provides a process for mechanically working ferrous metals at elevated temperatures to impart residual compressive stress so as to increase the endurance limit or fatigue resistance.

According to the inventor, the degree of residual stress imparted can be increased about two-fold without adverse effects by the following method: The steel is first austenitized by heating above the critical temperature. It is then quenched rapidly in a bath maintained above the temperature range of martensite formation, and held for a length of time sufficient to attain the bath temperature, but not long enough for transformation of the austenite to occur. This is followed by mechanical working. Finally, the steel is cooled to room temperature.

The inventor also claims that a more complete transformation to martensite occurs, with a greater hardness.

METAL DESCALING

U.S. 2,717,845, issued September 13, 1955 to Ray E. Carter, describes a method of descaling stainless steel sheets or strips in a molten bath containing sodium hydride in sodium hydroxide. The sodium hydride acts on oxides only, whereas an acid bath attacks both oxides and the parent metal.

The novel feature of the invention is making a sodium hydride descaling operation continuous, the stainless steel running through the molten bath at a speed of 30 to 100 fpm

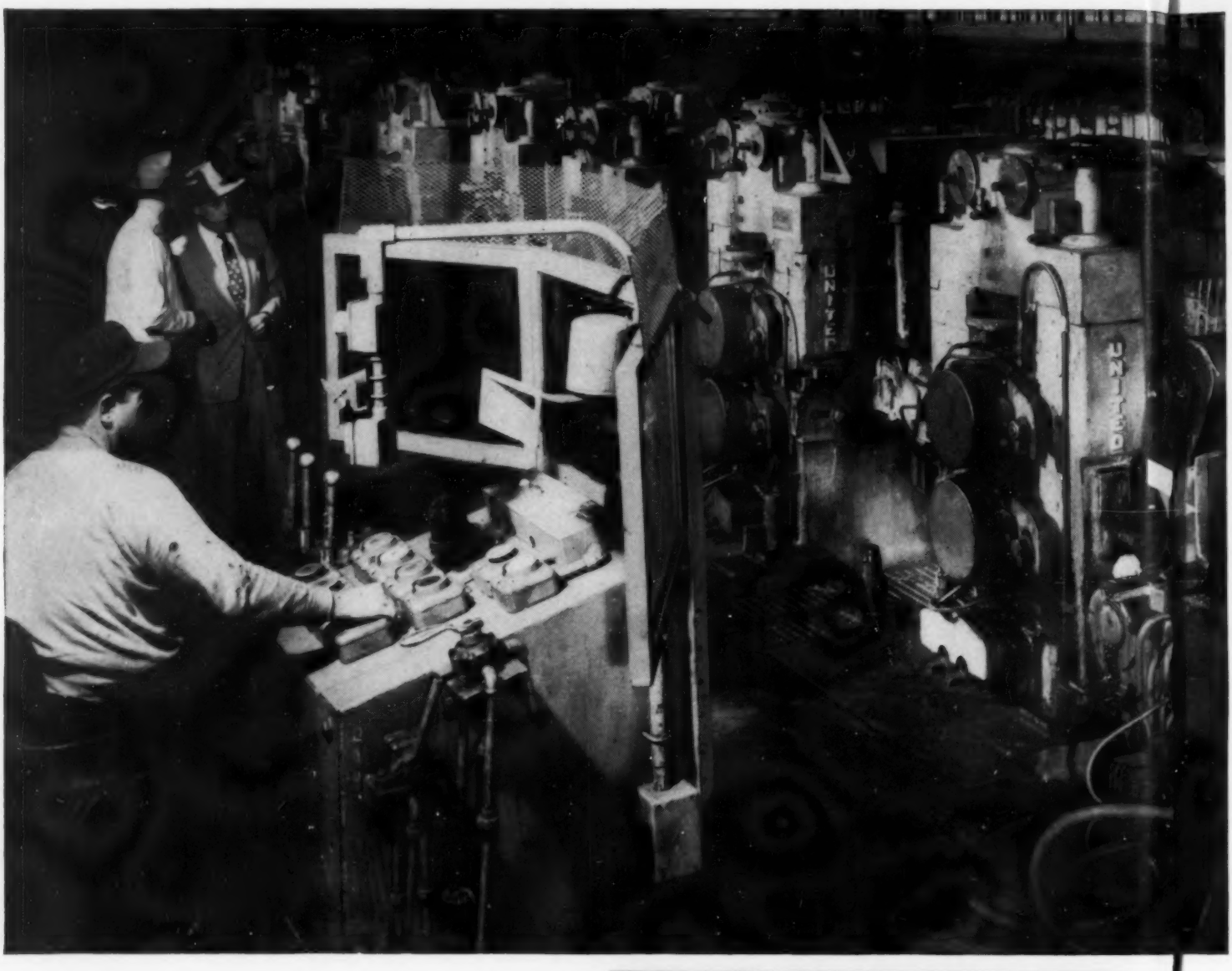
COOLING POWER OF QUENCHING BATHS

U.S. 2,717,515, issued September 13, 1955 to Manlio Pesante and assigned to Riv-Officine di Villar Perosa Societa per Azioni, describes an apparatus for determining the cooling power of quenching baths.

The invention is based on the observation that the "cooling power" of a quenching bath is defined by a curve of cooling speed versus temperature, where "cooling speed" is the rate of decrease of temperature with time. The apparatus permits direct determination of this curve without necessitating any intermediate calculation.

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,716,602	8/30/55	Composition for treating nodular iron	Ford Motor Co.
2,716,604	8/30/55	Process for producing nodular iron	Ford Motor Co.
2,716,687-8	8/30/55	Apparatus for working metal sheets	Loftus Engineering Corp.
2,716,967	9/ 6/55	Archless door frames for open-hearth furnaces	United States Steel Corp.
2,716,989	9/ 6/55	Apparatus for treating metal articles	Holcroft & Co.
2,717,072	9/ 6/55	Stock drawing apparatus for use in drawing tubes	Calumet & Hecla, Inc.
2,717,326	9/ 6/55	Electric arc furnace control systems	General Electric Co.
2,717,564	9/13/55	Roof structure for open-hearth furnaces	Carl Kreutzer



Mr. H. T. Anderson, Jones & Laughlin Lubrication Engineer and Gulf Sales Engineer C. D. Gilchrist discuss lubrication of the 11-inch rod mill. Gulf E.P. Lubricants provide effective protection for the pinion stands and gear drives, while Gulf XXX Lubricant safeguards the roll neck bearings.

Finishing train pinion stands also get effective lubrication with Gulf E.P. Lubricants.

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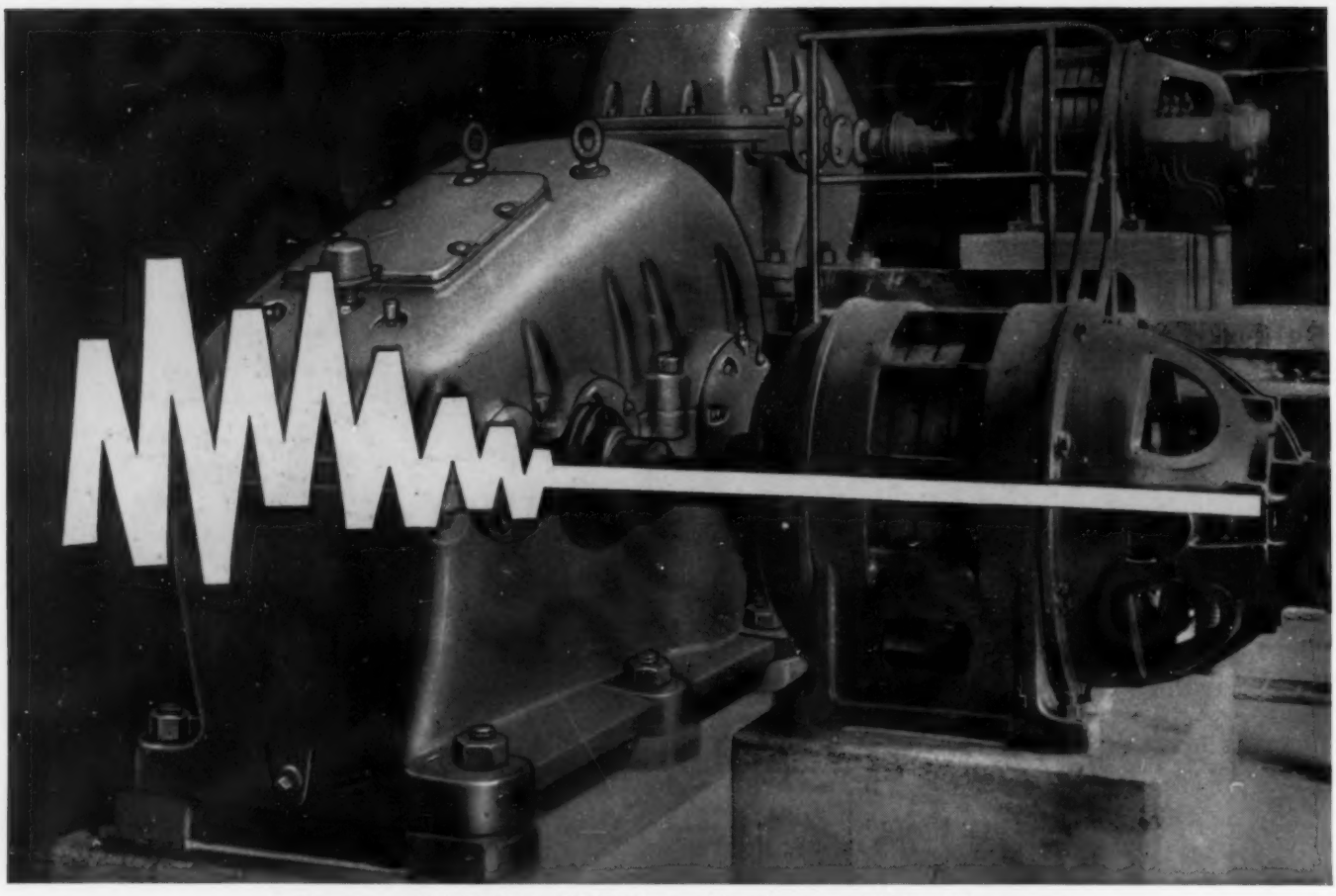
February 4, 1956

JUNIOR ACHIEVEMENT

THE FINEST PETROLEUM PRODUCTS FOR ALL YOUR NEEDS



Compact, rugged Link-Belt Parallel Shaft Drive "shrugs off" shock loads. Available with ratios up to 300:1 and horsepower capacities to over 2000.

Rugged LINK-BELT Parallel Shaft Drives

"shrug off" shock loads

WHEN it comes to judging a drive's resistance to shock and frequent overloading, ratings tell only half the story. It's these construction refinements of Link-Belt Parallel Shaft Drives that give you further assurance of long-range speed reduction economy:

GEARS are precision machined, shafts rigidly supported.

BALL AND ROLLER BEARINGS are used throughout.

GREASE-LUBRICATED SEALS block shaft openings to dirt.

AUTOMATIC SPLASH LUBRICATION cuts maintenance.

You'll find, too, that Link-Belt has simplified inspection and maintenance by making all parts accessible without disturbing the base. And to prevent reverse rotation on conveyors, elevators and similar equipment, a built-in backstop can be provided.

There are many more facts worth knowing—as well as specifications and application data — in Book 2619, available from your Link-Belt office or authorized stock-carrying distributor. Or write direct.

Get JOB-MATED drive combinations from the complete Link-Belt line

In addition to parallel shaft gear drives, Link-Belt builds in-line helical and worm gear drives, Gearmotors, Motogears, variable speed drives, fluid drives, chains, sprockets, couplings, bearings, etc. All are pre-engineered for easy installation and maximum efficiency.

LINK-BELT

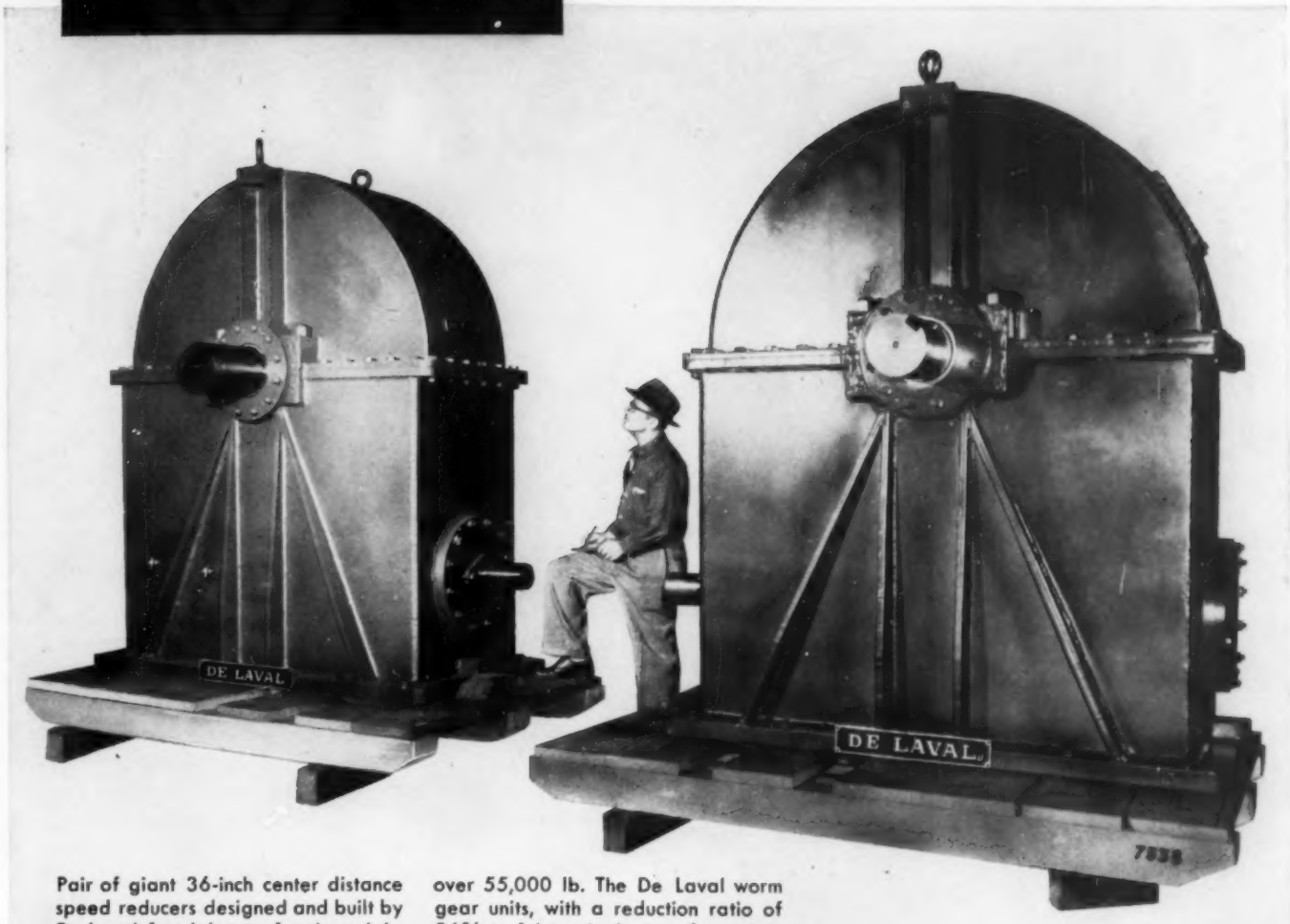
ENCLOSED DRIVES

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

13.955

DE LAVAL
SPEED REDUCERS

from dwarf to giant size



Pair of giant 36-inch center distance speed reducers designed and built by De Laval for slab transfers in a slabbing-blooming mill. These slab transfers are used to convey steel slabs up to 12 in. thick and 42 in. wide, weighing over 55,000 lb. The De Laval worm gear units, with a reduction ratio of 26⅔ to 1 in a single set of gearing, are each driven by a 200 hp, 410 rpm motor coupled directly to the input shafts of the slab transfers.

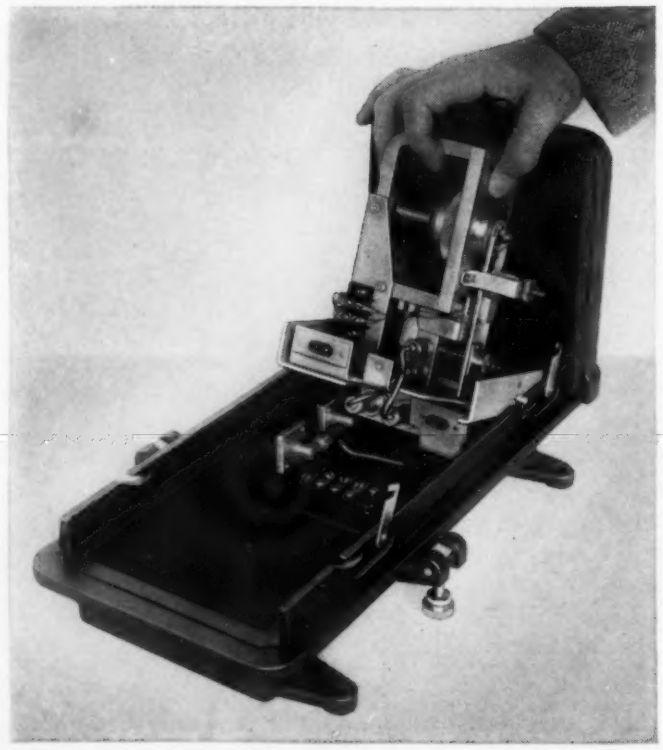
Here's one of the smaller De Laval worm gear speed reducers with a 3″ center distance being used for a new coal drilling machine.

De Laval heavy-duty worm gear speed reducers seldom require attention under the most rugged operating conditions. They make a quiet, close-couple compact drive. They permit high ratio reductions in a minimum of space and withstand severe shock loads without damage. De Laval builds all sizes from 3″ to 36″ center distances for transmission ratios of 3.1:1 to 100:1 in single reduction units and ratios of 50:1 to 8000:1 in double reduction units. Whether you need dwarf or giant worm gearing, consult De Laval for engineering assistance. *Send for De Laval Manuals G-WBV and G-WWH containing data on single and double reduction units.*

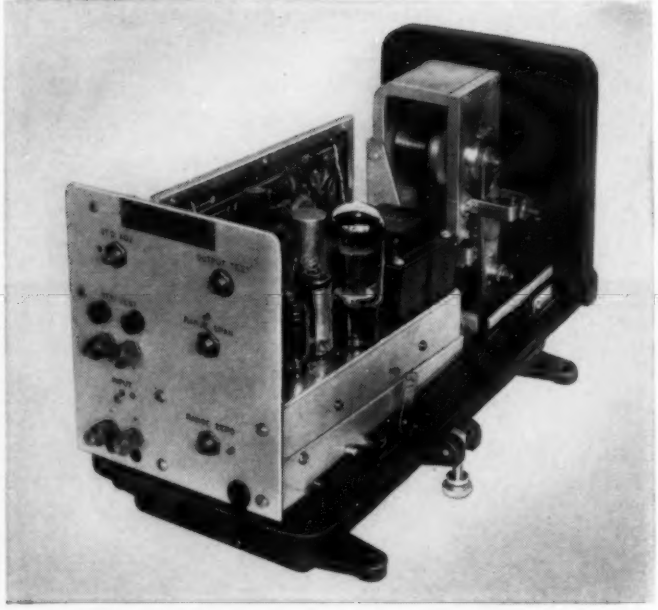
DE LAVAL *Speed Reducers*

DE LAVAL STEAM TURBINE COMPANY
870 Nottingham Way, Trenton 2, New Jersey DL210

Now! A TAYLOR



Plugging in the Transducer. This exclusive plug-in feature applies to both the transducer and the amplifier. Means quick, easy removal for service; minimum instrument down-time; checking can be done in the shop where full facilities are available. Also permits separate calibration.



Plugging in the Amplifier. See how easily units are locked into the chassis. Also note screwdriver adjustment of range span and zero suppression by virtue of unique potential dividers. Exclusive Taylor vernier adjustment permits resolution of 1 part in 100,000.

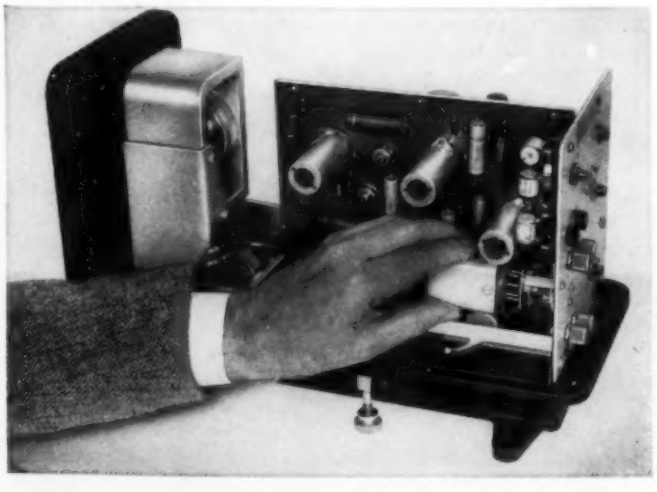
POTENTIOMETER TRANSMITTER

with all the innovations, ruggedness, dependability and versatility that industry expects from Taylor

TAYLOR has broadened its base of measurement with the introduction of an electronic instrument that extends the versatility of its pneumatic controllers and receivers. The TRANSET* Potentiometer Transmitter is a completely adaptable instrument for the measurement of a wide variety of variables, and can be quickly modified for use with different electrical primary elements. This ingenious instrument reflects Taylor's years of experience and knowledge of the requirements of the processing industries.

The TRANSET Potentiometer is especially adaptable where processing conditions require pneumatic controllers and receivers, and where conventional measuring circuits have not proved adequate. In thermocouple applications, for example, it can accurately measure temperatures within limits of minus 320°F. to plus 3272°F., with range spans as short as 100°F., depending upon the characteristics of the thermocouple used.

*Reg. U.S. Pat. Off.



Plugging in the Input Circuit Board. It can be quickly adapted for use with different primary elements by simply plugging in the corresponding input circuit; e.g., for thermocouple applications cold junction compensation is provided in the plug-in circuit board. One instrument can therefore be used as a spare wherever a transmitting potentiometer is used.

Why experienced instrument men say— "most practical instrument of its kind"

1. The unit is automatically, continuously standardized and offers complete electronic balance, permitting optimum response adjustments. There are no slide wires or motor drive.

2. High Input impedance. No need to match resistance of leads.

3. Output impedance is virtually infinite. Its 0 - 5 milliamp signal can perform multiple auxiliary functions without affecting accuracy of pneumatic signal.

4. Range span and zero suppression adjustments are easily made by screwdriver due to unique design of high resolution potential dividers.

5. Both electronic and pneumatic units plug-in. Simplifies service; permits separate calibration.

6. Normal load is automatically inserted when amplifier is removed for service.

7. Modern printed circuits insure uniform performance. Test terminals provided for trouble shooting.

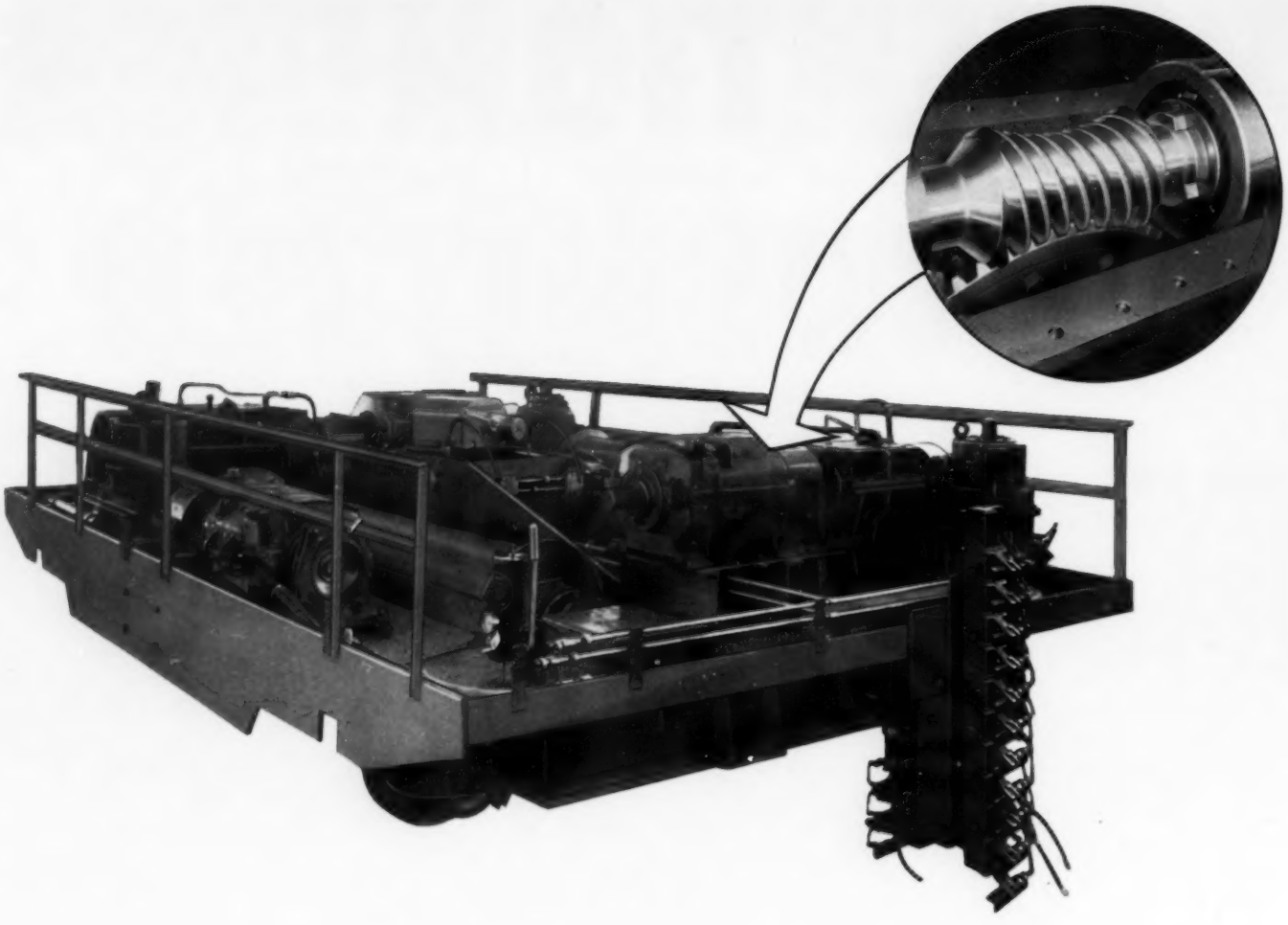
8. Three-circuit jack on front panel permits easy monitoring of output current. Convenient pin jacks provided for checking standardization voltage.

9. Three-piece, purged cast-aluminum case is moisture and corrosion proof. All adjustments are readily accessible.

10. If used only for scanning, logging or similar auxiliary functions the instrument is available without transducer.

Write for Bulletin *98262. Taylor Instrument Companies, Rochester, N.Y., and Toronto, Canada.

Taylor Instruments
MEAN
ACCURACY FIRST
IN HOME AND INDUSTRY



WORM GEARED TROLLEYS TO A.I.S.E. SPEC'S... *by "Shaw-Box"*

For those who prefer worm gearing, this 30-ton trolley with 5-ton auxiliary hoist — both worm geared and built to A.I.S.E. specifications — is a typical example of how "Shaw-Box" interprets these specifications.

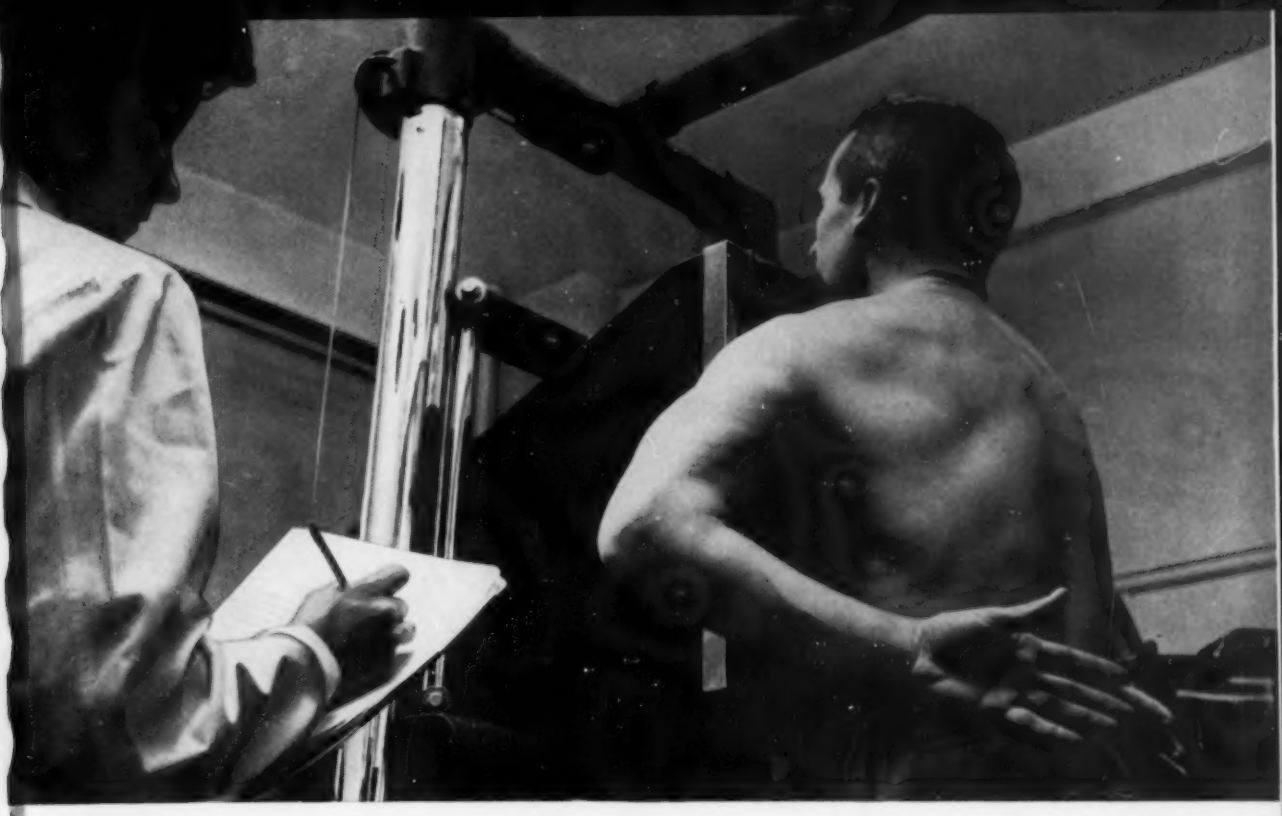
Whichever you prefer — spur or worm gearing — you will do better with "Shaw-Box" trolleys. We've built many cranes, ranging from 5 to 200 tons capacity, to A.I.S.E. specifications No. 6. In all "Shaw-Box" Cranes — whether built to an individual mill's or A.I.S.E. specifications — you get the added advantages that come from more than 65 years of building overhead load-handling equipment exclusively; as well as from "Shaw-Box" engineering, fine workmanship, and precision manufacturing methods.

SEND ALL YOUR INQUIRIES FOR CRANES AND SOAKING PIT CARRIAGES TO "SHAW-BOX."

"Shaw-Box" CRANES

MANNING, MAXWELL & MOORE, INC.
Muskegon, Michigan

Builders of "Shaw-Box" Cranes, 'Budgit' and 'Load Lifter' Hoists and other lifting specialties. Makers of 'Ashcroft' Gauges, 'Hancock Valves, 'Consolidated' Safety and Relief Valves, 'American' and 'American-Microsen' Industrial Instruments, and Aircraft Products.



GENERAL REFRACTORIES

better health . . . because of BRICK

It is hard to associate X-rays with brick—the refractory brick which contains the fires of industry. Yet, were it not for brick these fine X-ray machines would never be made, and there'd be no electricity to operate them.

From an autoclave to an automobile, from a scalpel to a skyscraper, everything that's made and every form of transportation, communication and power owe their existence to refractory brick.

Our job is to provide that brick. In infinite variety. Compounded to formulas as precise as a prescription, in the world's largest refractories research laboratory. Moulded from materials brought from many countries in plants strategically located across our country to serve industry swiftly . . . dependably . . . economically . . . everywhere.

GENERAL REFRACTORIES COMPANY
Philadelphia 2

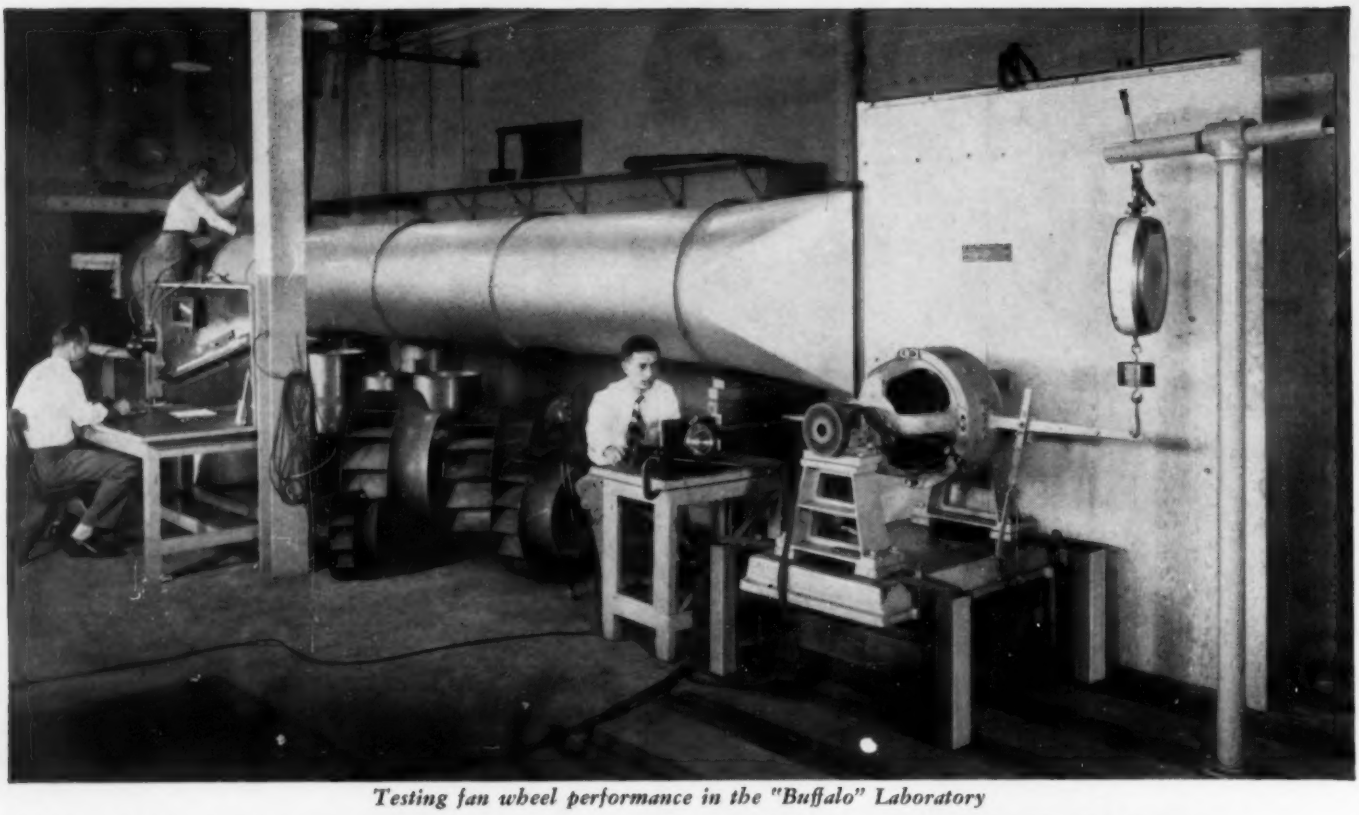
A COMPLETE REFRACTORIES SERVICE FOR THE STEEL INDUSTRY

OLIVE HILL BF and OLIVE HILL HI-FIRED brick rank high in any list of prominent and widely used brands of blast furnace refractories. Manufactured from dense-burning Kentucky flint fire clays by Grefco's unique manufacturing processes, OLIVE HILL brick set a standard for blast furnace refractory quality and workmanship.

Grefco processing of OLIVE HILL brick entails:

1. Careful selection, testing, stockpiling and blending of fire clays to insure uniform raw material quality.
2. Grinding and screening to prescribed formula to promote high density of product.
3. Efficient deairing during brick forming, also to promote density and proper physical structure.
4. Careful firing to exacting temperature schedules to yield uniform high quality brick.
5. Close inspection of final product with gauging and sorting of brick to close size tolerance.
6. Quality control by statistical analysis procedures for the manufacturing processes.

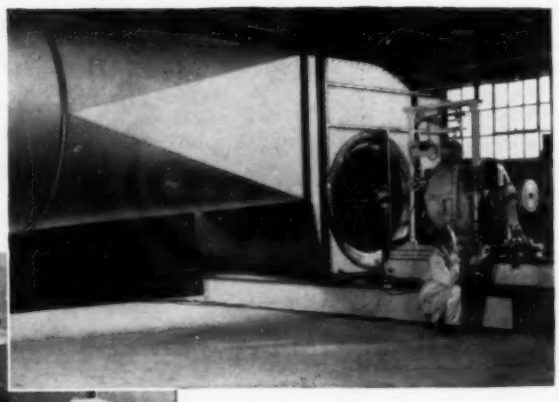
In service, OLIVE HILL blast furnace brick, both BF and HI-FIRED, have produced many splendid performance records in the past. OLIVE HILL linings in presently operating furnaces, are giving outstanding performance and are more than meeting the increasing requirements of the expanding American Iron and Steel Industry.



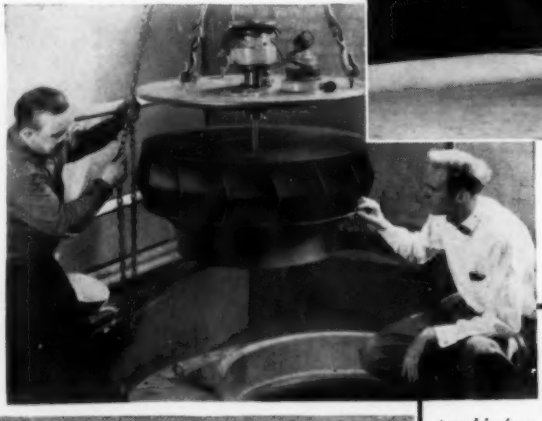
Testing fan wheel performance in the "Buffalo" Laboratory

WHY "BUFFALO" FANS PERFORM* AS SPECIFIED

What will this wheel design deliver at various static pressures? What are the horsepower requirements? Noise level? And what's the best housing? Endless testing like this in the "Buffalo" Laboratory — plus endless designing and redesigning — brought you the famous high-performance Type BL Limit-Load Ventilating Fan — and will continue to bring you the latest and finest in fans. You can expect this inbuilt performance whenever you order a "Buffalo" Centrifugal, axial flow or propeller fan.



WHERE WE TRY TO DESTROY WHEELS — the "Buffalo" vacuum test pit where wheels are revolved at many times their operating speeds to discover — and correct — any point of structural weakness. Further assurance of a better fan buy when you specify "Buffalo".



ALL TESTS in the complete "Buffalo" laboratory are conducted in strict accordance with the test code adopted jointly by NAFM and ASH&VE.

**Performance—another term for the "Buffalo" "Q" Factor—the built-in Quality which provides trouble-free satisfaction and long life.*

"Buffalo"

BUFFALO FORGE COMPANY

173 MORTIMER STREET BUFFALO, N. Y.

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

Sales Representatives in all Principal Cities

VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT EXHAUSTING

FORCED DRAFT COOLING HEATING PRESSURE BLOWING

The Results of this Important Research Project are basic to every man who faces a Rust Problem

RUST-OLEUM®
A CORPORATION
STOPS RUST!

CHICAGO • BRIARGATE 4-4000 • EVANSTON • GREENLEAF 5-1010
EVANSTON • ILLINOIS

September 15, 1956

SUBJECT: Special Report to Industry

It is generally recognized by engineers and corrosion experts that there is far more to stopping rust on a rusted surface, than just applying any type of material at a certain film thickness. Dry film thickness of a protective coating is important--but, it's what goes on UNDER the film surface that counts, too. The vehicle of the coating that's applied over rust must penetrate to bare metal, driving out the air and moisture that, in presence of metal, cause rust.

Rust-Oleum users, for over thirty years, have known that Rust-Oleum does exactly that through practical use and results of the application of the product. However, Rust-Oleum wanted to go even further in bringing you irrefutable proof of this penetration.

With this in mind, the Rust-Oleum Corporation consulted with technologists from the Battelle Memorial Institute in Columbus, Ohio, who conducted this important research project, utilizing radioactive tracing technique with C^{14} radioisotope to measure Rust-Oleum penetration. Now, after nearly three years of continued research, you can actually look UNDER the surface film and see how the Rust-Oleum specially-processed fish oil vehicle penetrates rust to bare metal.

The methods and results of this research, which are outlined on the following pages, are given in their entirety in a thirty-page report entitled, "The Development of a Method to Determine The Degree of Penetration of a Rust-Oleum Fish-Oil-Based Coating Into Rust Coatings on Steel Specimens," prepared by Battelle Memorial Institute technologists. It is available to you without cost or obligation by request on your business letterhead.

Very truly yours,

RUST-OLEUM

Robert A

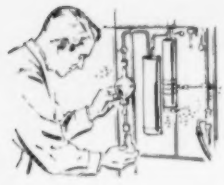
President

RAF/jc

Now! For the first time, actually look *under* the surface of the coating! See Rust-Oleum *penetrate rust* to bare metal through the "eyes" of radioactivity!

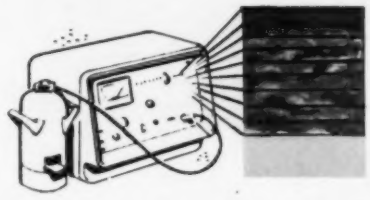
(A RUST-OLEUM REPORT TO EVERY PERSON FACED WITH A RUST PROBLEM)

Nearly three years of research, utilizing radioactive tracing with C^{14} radioisotope, enables you to follow Rust-Oleum penetration through the heretofore "unseen" rust area to bare metal. While Rust-Oleum users, for over thirty years, have known that Rust-Oleum penetrates rust to bare metal when applied over rusted surfaces—Rust-Oleum wanted to go even further in bringing irrefutable evidence of this penetration to you. The methods and results, on which the technical information on these pages is largely based, are presented in a complete thirty page report entitled, "The Development of a Method to Determine The Degree of Penetration of a Rust-Oleum Fish-Oil-Based Coating Into Rust Coatings on Steel Specimens," prepared by Battelle Memorial Institute technologists. Request your copy on your business letterhead without cost or obligation.



1 To trace Rust-Oleum penetration through rust, the Rust-Oleum fish oil vehicle was made radioactive with C^{14} radioisotope. The radioactive Rust-Oleum fish oil vehicle was then formulated into Rust-Oleum 769 Damp-Proof Red Primer without changing Rust-Oleum's exclusive formulation or performance of product.

2 Rusted metal test panels were scraped and wirebrushed to remove rust scale and loose rust, according to Rust-Oleum's standard directions for application. The radioactive Rust-Oleum 769 Damp-Proof Red Primer was then brushed on directly over the remaining rust on these rusted test panels and allowed to dry.



3 Then—the surfaces of the rusted panels were shaved at approximate half-mil levels and Geiger Counter readings of Rust-Oleum penetration (radioactivity) were taken at each level down to bare metal. These measurements are shown as "Percentage of Surface Radioactivity" figures on the graph on the opposite page.

Dry film thickness of a coating is important, but, what goes on UNDER the film surface is vitally important, too, in the stopping of rust. Rust-Oleum Stops Rust, because it penetrates the rust to bare metal. The Rust-Oleum fish oil vehicle works around the rust particles and through the fissures and crevices in the rust formation to the bare metal. It doesn't "bridge-over" the tiny, microscopic pits in the metal—BUT, actually goes into these pits to drive out air and moisture and coat the metal with a penetrating, low-surface-tension film that expands and contracts with the metal. Because of this unusual penetration, you can apply Rust-Oleum 769 Damp-Proof Red Primer directly over the rusted surface after scraping and wirebrushing to remove rust scale and loose rust. Thus—you save time, labor, and money as costly surface preparations are usually eliminated.

From tanks, girders, machinery, roofs, sash, stacks, pipes, wire fences, and building maintenance in industry . . . marine, farm, or railroad applications . . . to gutters, metal sash, lawn furniture, etc. around the home . . . Rust-Oleum is the modern way to Stop Rust and beautify as you protect, in your choice of Red, White, Black, Aluminum, Gray, Green, Yellow, Blue, etc. May be applied by brush or spray and dries to a firm, *decorative* coating that resists salt water, salt air, heat, fumes, sun, humidity, and weathering. Industrial users see Sweets for complete catalog and nearest Rust-Oleum Distributor, or attach coupon on the opposite page to your business letterhead for complete information, including your thirty-page report on Rust-Oleum penetration. Homeowners will find Rust-Oleum featured at leading Hardware, Paint, and Lumber dealers in most localities.

there is only one Rust-Oleum . . . *it is distinctive as your own fingerprint*

RUST-OLEUM®

STOPS RUST!

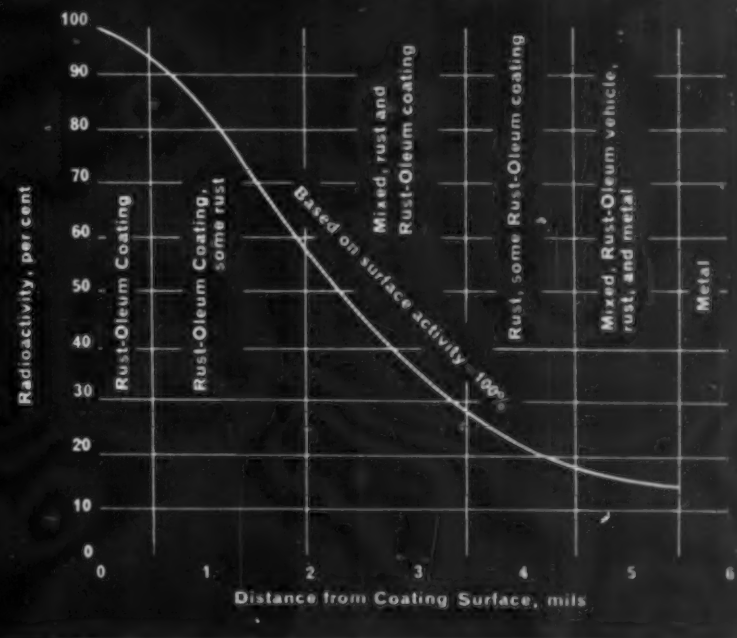
Rust-Oleum is exclusive. It incorporates a specially-processed fish oil vehicle that penetrates through rust to bare metal. It dries right and is free of objectionable odor. Many attractive colors.

A new Rust-Oleum development is the Rust-Oleum Galvinoleum coating. It sticks to new or old galvanized surfaces *without* etching, *without* weathering. Available in red, gray, green, metallic.

Photomicrograph (enlarged 250 times) of cross-section of rusted metal coated with Rust-Oleum.

Actual unretouched photomicrograph (enlarged 250 times) showing cross-section of rusted metal coated with Rust-Oleum. Geiger Counter readings were taken at each half-mil level down through the rust—tracing Rust-Oleum penetration through rust to bare metal.

Graph (at right) shows Geiger Counter recordings of Rust-Oleum penetration. Visible evidence of Rust-Oleum penetration as recorded by Geiger Counter and Gas Flow Proportional Counter is shown on graph. Rust-Oleum penetration is expressed in terms of "Percentage of Surface Radioactivity" figures at given mil levels. Note how Rust-Oleum pigment and fish oil vehicle combined penetrate to approximately four mils—then the fish oil vehicle penetrates through remaining rust to bare metal.



GET THE COMPLETE STORY. ATTACH TO YOUR BUSINESS LETTERHEAD FOR YOUR COPY OF THIRTY-PAGE REPORT WITHOUT COST OR OBLIGATION.

Rust-Oleum Corporation
2980 Oakton Street, Evanston, Illinois

- ☐ Please send me without cost or obligation, the Rust-Oleum thirty-page report entitled, "The Development of a Method To Determine The Degree of Penetration of a Rust-Oleum Fish-Oil-Based Coating Into Rust Coatings On Steel Specimens," as prepared by Battelle Memorial Institute technologists.
- ☐ Complete literature and color charts.
- ☐ Nearest source of supply.

...there is only one Rust-Oleum...it is distinctive as your own fingerprint

RUST-OLEUM IS EXCLUSIVE. Most manufacturers of protective materials specify that rusted metal surfaces must be free of rust before applying their product. Rust-Oleum does NOT! With Rust-Oleum you simply scrape and wirebrush to remove rust scale and loose rust —then brush Rust-Oleum 769 Damp-Proof Red Primer directly over the remaining rust. The specially-processed fish oil vehicle penetrates rust to bare metal, merging the rust particles into the coating. It dries to a firm, decorative coating that resists salt water, salt air, heat, fumes, humidity, sun, moisture, and weathering. This unusual penetration saves you time, labor, money, and metal because sandblasting, chemical pre-cleaning, and other costly surface preparations are usually eliminated.

AVAILABLE IN *MANY COLORS.* You beautify as you protect because Rust-Oleum is available in many, many attractive colors including Aluminum, White, Black, Green, Red, Gray, Orange, Yellow, Blue, etc. In addition to industrial rust preventive coatings, Rust-Oleum finish coatings, incorporating the same specially-processed fish oil vehicle, are available (1) to match original equipment manufacturer's colors for farm and road and highway construction equipment, (2) Oil Field finishes to match original equipment colors for rigs, pumps, etc., (3) Restful Colors for plant and institutional interiors, (4) Special Marine and Railroad finishes, (5) Heat Resistant and Chemical Resistant finishes, (6) Masonry and Floor Coatings.

RUST-OLEUM®

Remember—Rust-Oleum's unusual rust-resistant qualities enable you to apply Rust-Oleum 769 Damp-Proof Red Primer one season—and wait until the following season to use your Rust-Oleum finish coating. Thus—you "stretch" maintenance budgets season-to-season.

STOPS RUST!

Write on your business letterhead for your copy of the special Rust-Oleum thirty-page report, entitled, "The Development of a Method to Determine The Degree of Penetration of a Rust-Oleum Fish-Oil-Based Coating Into Rust Coatings on Steel Specimens." We'll be glad to send it to you promptly, and there is no cost or obligation.

Rust-Oleum Corporation • 2980 Oakton Street • Evanston, Illinois

Mechanized oxygen cutting cuts heavy scrap—and costs!

Teamwork between a large eastern steel mill and Air Reduction made possible this modern mechanized oxygen cutting installation.

Heavy scrap is reduced rapidly to size for open-hearth furnaces by Airco's No. 50 Travograph equipped with heavy-duty cutting torch on elevated rails. Result: cost of steel manufacture reduced by way of saving in man hours, better scrap preparation and consequent increase of production.

Mechanized oxygen cutting is but one of the many ways in which Airco can put its special techniques to work for you. Perhaps you have a problem of either a confined work area requiring a centralized cutting operation, or a large work area that calls for mobile cutting equipment. Airco Technical Sales Representatives are ready to place their experience and knowledge at your service. Their advice and recommendations can be invaluable in improving and simplifying your production. For more information, write for Airco Bulletin ADR 97.

AIRCO®

AIR REDUCTION

60 East 42nd Street • New York 17, N. Y.

Divisions of Air Reduction Company, Incorporated, with offices and dealers in most principal cities

Air Reduction Sales Company
Air Reduction Pacific Company
Represented Internationally by
Airco Company International

Foreign Subsidiaries:
Air Reduction Canada Limited
Cuban Air Products Corporation

Products of the divisions of Air Reduction Company, Incorporated, include: **AIRCO** — industrial gases, welding and cutting equipment, and acetylenic chemicals • **PURECO** — carbon dioxide, liquid-solid ("DRY-ICE") • **OHIO** — medical gases and hospital equipment • **NATIONAL CARBIDE** — pipeline acetylene and calcium carbide • **COLTON** — polyvinyl acetates, alcohols, and other synthetic resins.

It's Allis-Chalmers ..

Motors, M-G Sets, Control, Switchgear... Dependable Allis-Chalmers Electrical Equipment Plays an Important Role in Steel Mill Expansion Programs

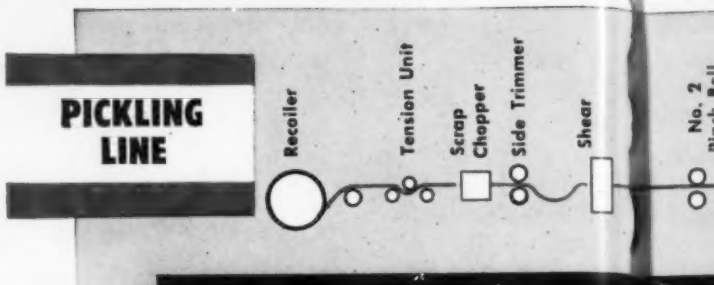
Demand for specialized steel remains at a record high. Steel producers are meeting the challenge with improvements on existing processing lines, or installation of new facilities for pickling and annealing operations.

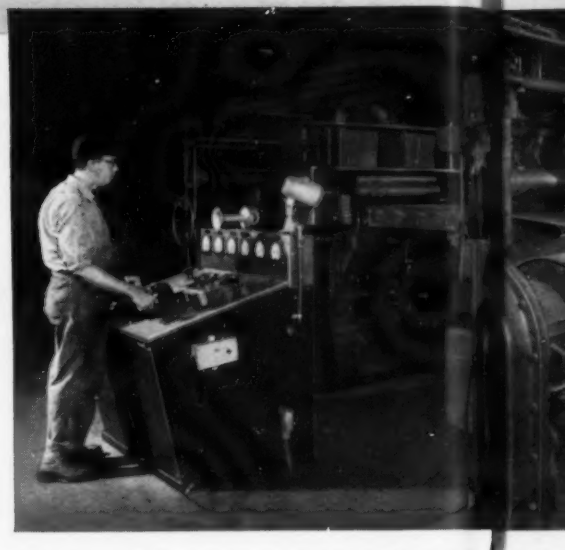
A recent installation of this type in an eastern steel mill featured Allis-Chalmers motors, m-g sets, control and operating stations, and switchgear throughout.

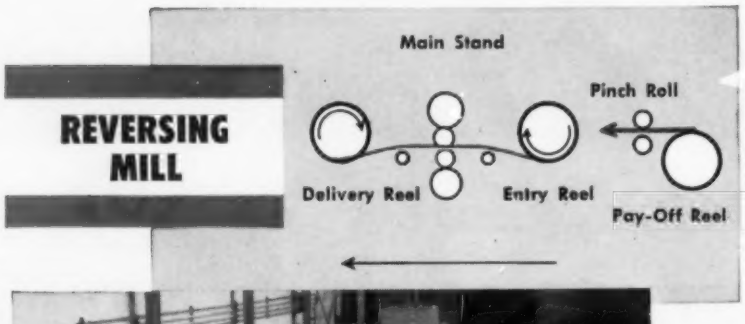
Allis-Chalmers equipment was chosen for this duty because of its record of quality, economy, durability... proven in years of heavy-duty steel mill operation.

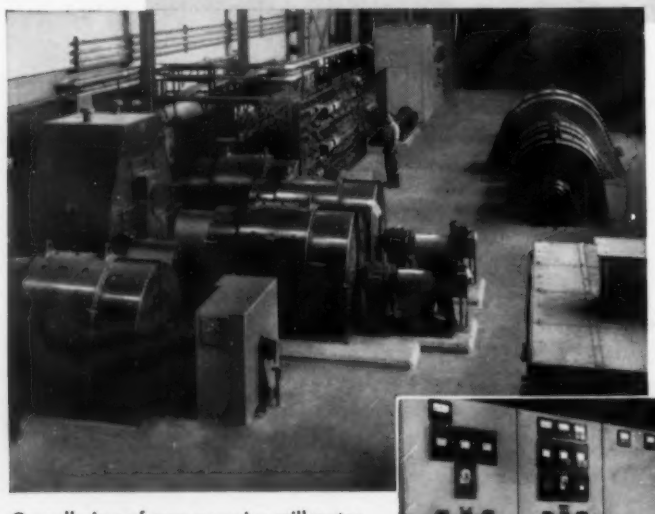
Take advantage of Allis-Chalmers wide range of equipment and service. For help in planning new facilities or modernizing present plants, contact the A-C office in your district, or write Allis-Chalmers, Milwaukee 1, Wisconsin.

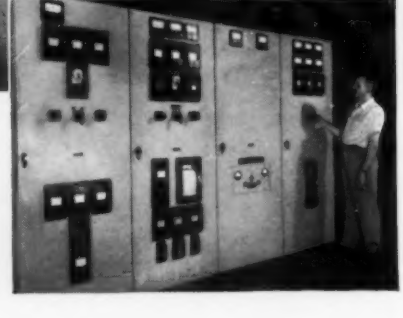
A-4872



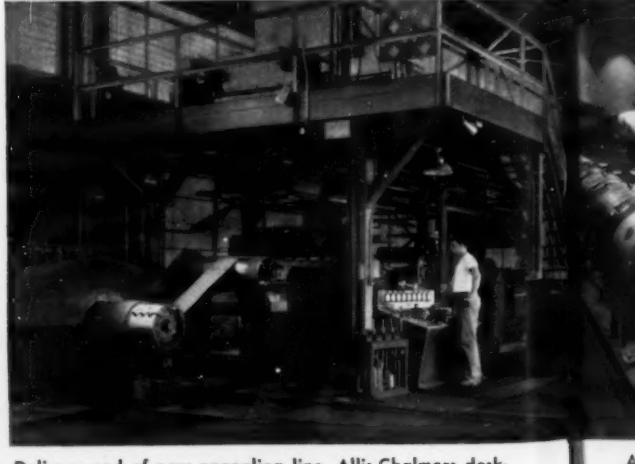








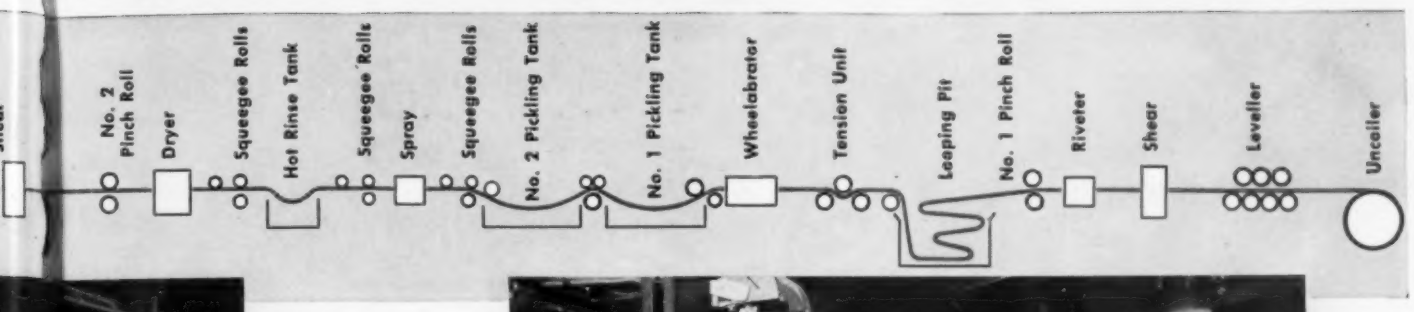
Overall view of new reversing mill motor room showing main motors, m-g sets, control, and 11,000/480-volt substation. Inset shows Allis-Chalmers 15-kv high voltage switching equipment for the motor-generator set and substation.

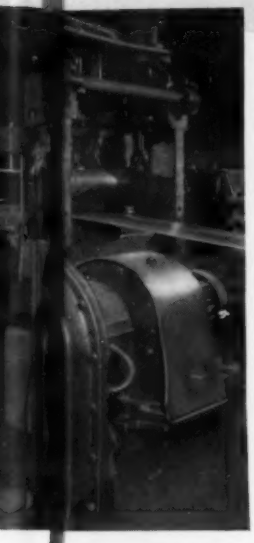


Delivery end of new annealing line. Allis-Chalmers desk-type operators' control stations, as shown here, are used throughout these modern new facilities.

ALLIS-

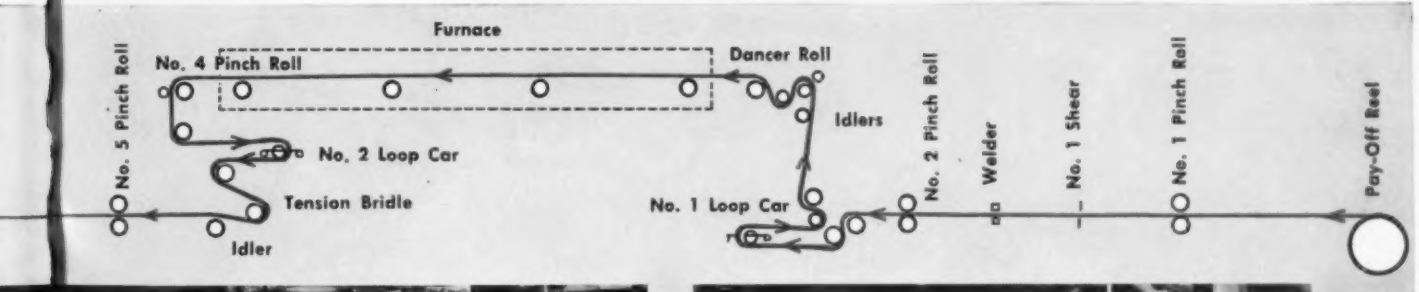
.. All Along the Line

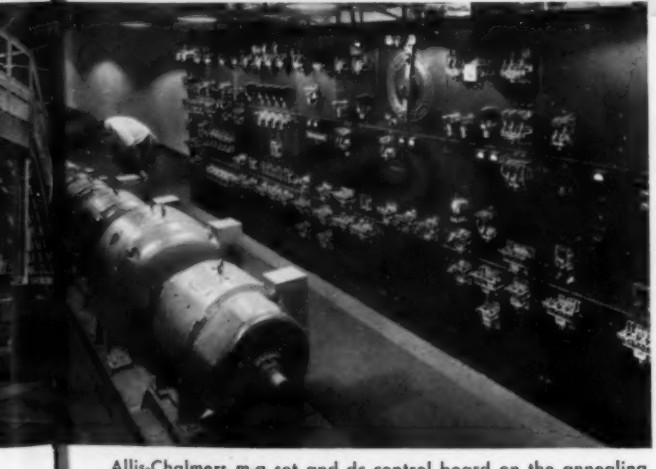




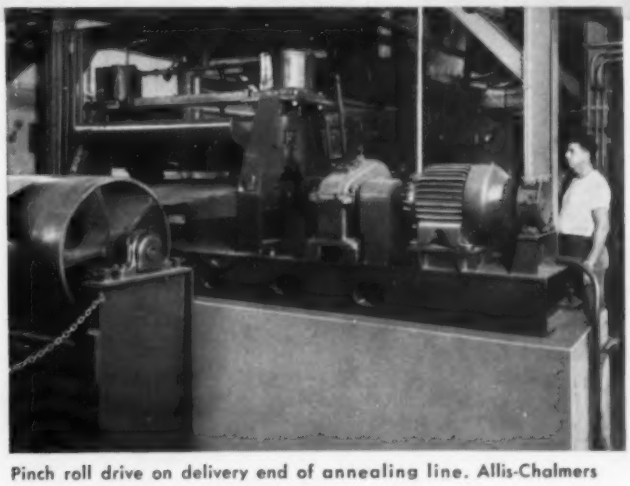
Operator's station, entry end, 36-inch hot-rolled pickling line. Allis-Chalmers control, initiated from desk, gives positive, precision control of material speed.

Allis-Chalmers dc control board and metering panels, m-g set, on delivery section of the pickling line.





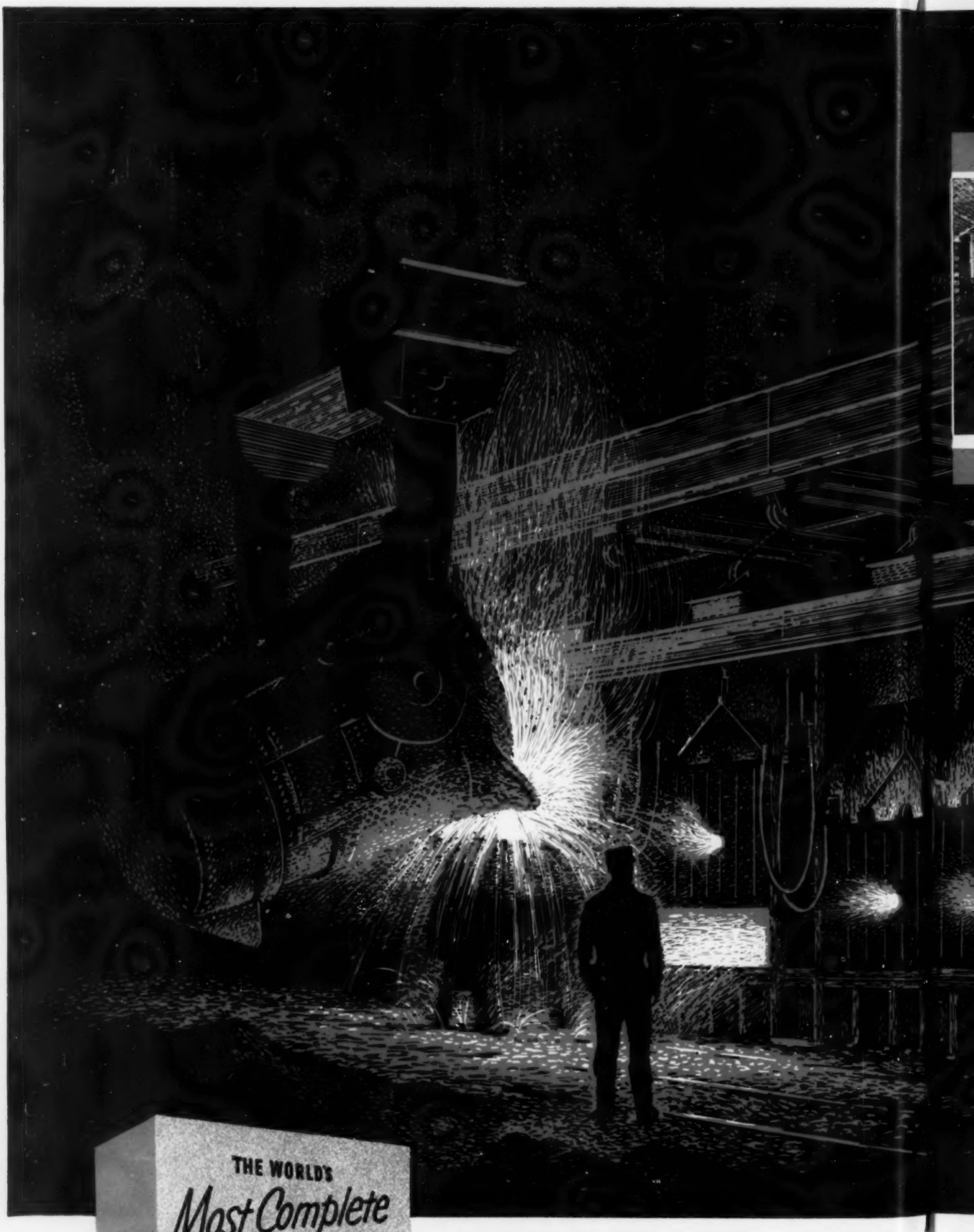
Allis-Chalmers m-g set and dc control board on the annealing line. Allis-Chalmers m-g sets and controls are recognized in the steel industry for dependable, economical service.



Pinch roll drive on delivery end of annealing line. Allis-Chalmers fan-cooled motors drive various parts of the processing line.

-CHALMERS

A-C ALLIS-CHALMERS



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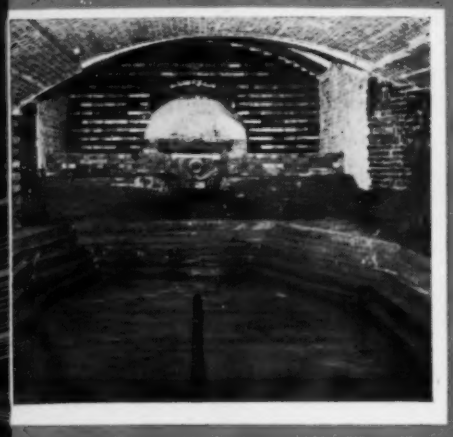

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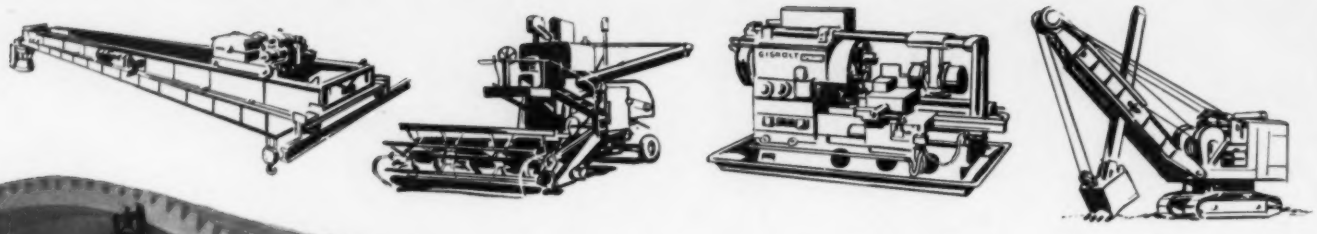

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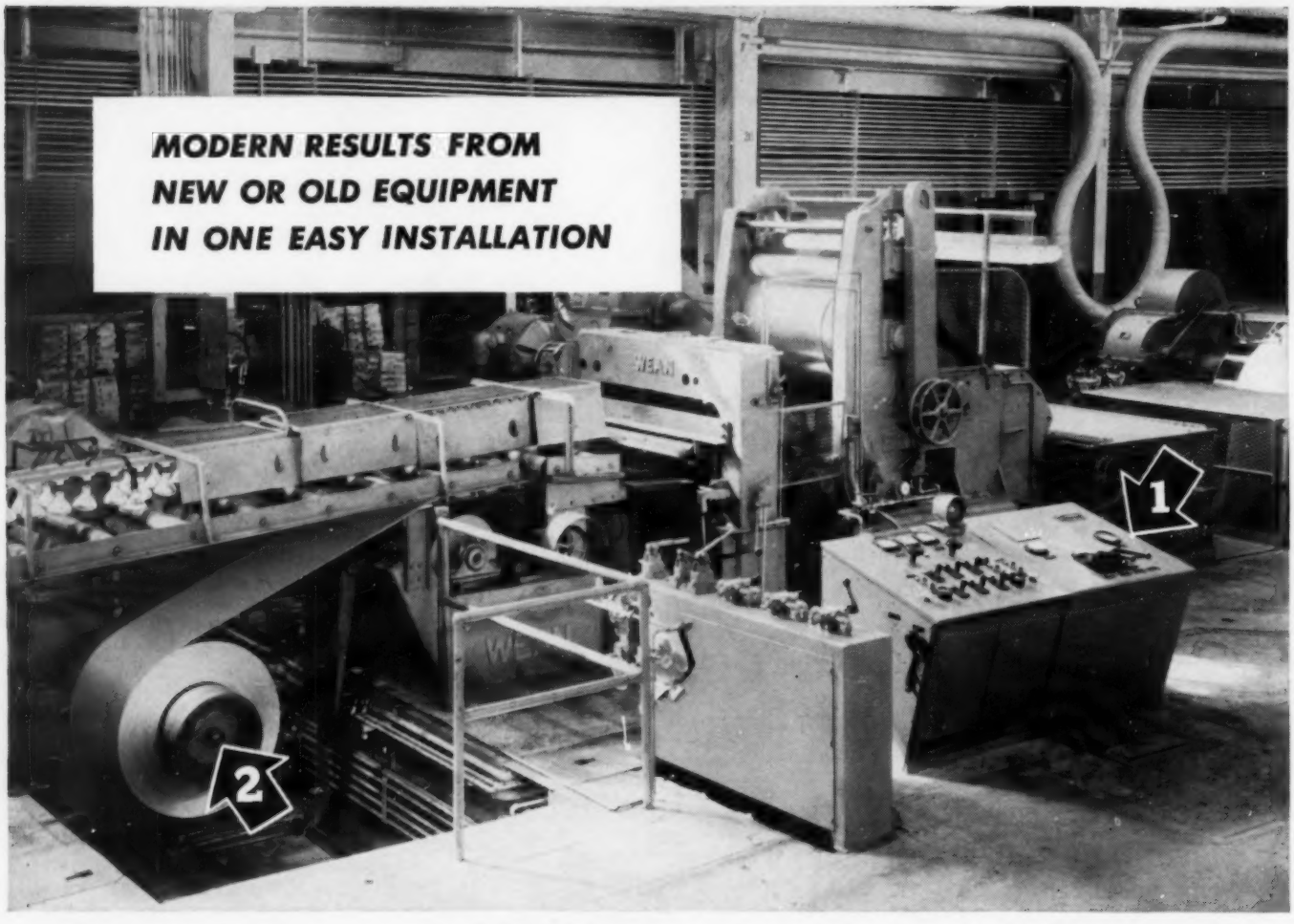

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ENGINEERING & COMPUTER SERVICE, VALVE ACTUATORS & CYLINDERS

CONTROLS FOR INDUSTRY

A Subsidiary of General Precision Equipment Corporation

WHY STEEL PRODUCTION COSTS GO DOWN WITH

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Crops and Shorts

ON December 16, 1955, the steel industry equaled its yearly steelmaking record set in 1953. The remainder of the month added to the 1955 production at the rate of about 343,000 tons per day to bring the 1955 total to just over 117,000,000 tons.

▲

AS the new year opens with booming business and blazing optimism, we find the steel industry going ahead with the throttle wide open. Among the usual new year statements, there are the following:

"The steel industry outlook in 1956 is for a year of good operations." — E. T. Weir, chairman, National Steel Corp.

". . . we think the steel industry is almost sure to turn out more steel in 1956 than it did in 1955." — W. W. Sebald, president, Armco Steel Corp.

". . . the first six months of 1956 should establish another new high in steel production with more than 60,000,000 tons of ingots . . . . I do not think the present pace of steel production will be maintained in the second half. The drop should not be great — possibly down to about 55,000,000 ton level." — J. L. Block, president, Inland Steel Co.

"There is every indication that steel consumption in the West will continue in 1956 at record levels." — J. L. Ashby, vice president, Kaiser Steel Corp.

". . . we will need 30,000,000 ingot tons of new steelmaking capacity over the next 10 years . . . . the industry is faced with a construction bill of $16,000,000,000 for capital improvements over the next ten years." — Admiral Ben Moreell, chairman, Jones & Laughlin Steel Corp.

". . . . prospects for a continuing high rate of production seem to be reasonably good. Backlog of orders already on our books is at the highest point in history for any year and record." — Henry Roemer, chairman, Sharon Steel Corp.

". . . the year 1956 will be one in which the economic activity of our country will continue at a high level." — E. O. Burgham, president, Weirton Steel Co.

"All indications point to continued high production, expansion and improvement in 1956." — M. D. Howell, executive vice president, American Iron and Steel Institute.

▲

THE consensus seems to indicate an ingot production for 1956 between 115,000,000 and 120,000,000 tons. Two good customers of the steel industry may fall off somewhat in 1956. Estimates for the automobile industry indicate it may operate 10-25 per cent under 1955, and home building may be off about 10 per cent. Industrial and commercial outlays for construction and new equipment, however, will be the largest on record.

▲

ONE cloud looms on the horizon in the form of labor negotiations which are due to come to a head on June 30. It is believed that the United Steel Workers of America will ask for wage increases, layoff protection for 52 weeks, premium pay for Saturday and Sunday work, a union shop and miscellaneous benefits. Quite a package!

▲

THE Wall Street Journal defines an old timer as one who remembers when he was tied to his mother's apron strings, not her Bermuda shorts.

▲

THE U. S. Department of Commerce estimates that by 1975, with prosperous peacetime conditions, the United States will be using 1,356,300,000,000 kwhr of electric energy a year, an increase of 209.2 per cent over 1953.

▲

POWERFAX, house organ of the Elliott Co., says a lot of brainy women earn their living, but the sensible ones let men do it for them.

▲

ACCORDING to the American Iron and Steel Institute, annual capacities of the industry as of January 1, 1956, are 128,363,090 net tons of steel, 85,485,230 net tons of iron, and 69,416,400 net tons of by-product coke.

▲

IT is estimated that about 2,000,000,000 Christmas cards (more than 40 per family) were sent by Americans during the recent holiday season.

▲

JOINING in the alphabetizing game so prevalent in government circles is W. Trinks, who volunteers a name for the recently merged American Federation of Labor and the Congress of Industrial Organizations — Afolcio, with the accent on the second syllable.

▲

ARMOUR Research Foundation of Illinois Institute of Technology is setting up a European office to funnel ideas and techniques of potential value in the American market to sixteen non-competing firms in the United States. The plan should appeal to small and medium-sized companies interested in keeping abreast of European research and development at little cost.

▲

TYPOGRAPHIC carries this lament:

I love my wife; my wife loves me.
I favor ties that bind.
But 'neath the tree on Christmas Day
I find some ties that blind.

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Better cleaning at lower cost has led Republic Steel Corp. to install the Wheelabrator mechanical descaling process to augment pickling in each of four strip lines in its Massillon, Ohio, plant. Chrome and chrome-nickel stainless coils are cleaned in preparation for cold rolling.

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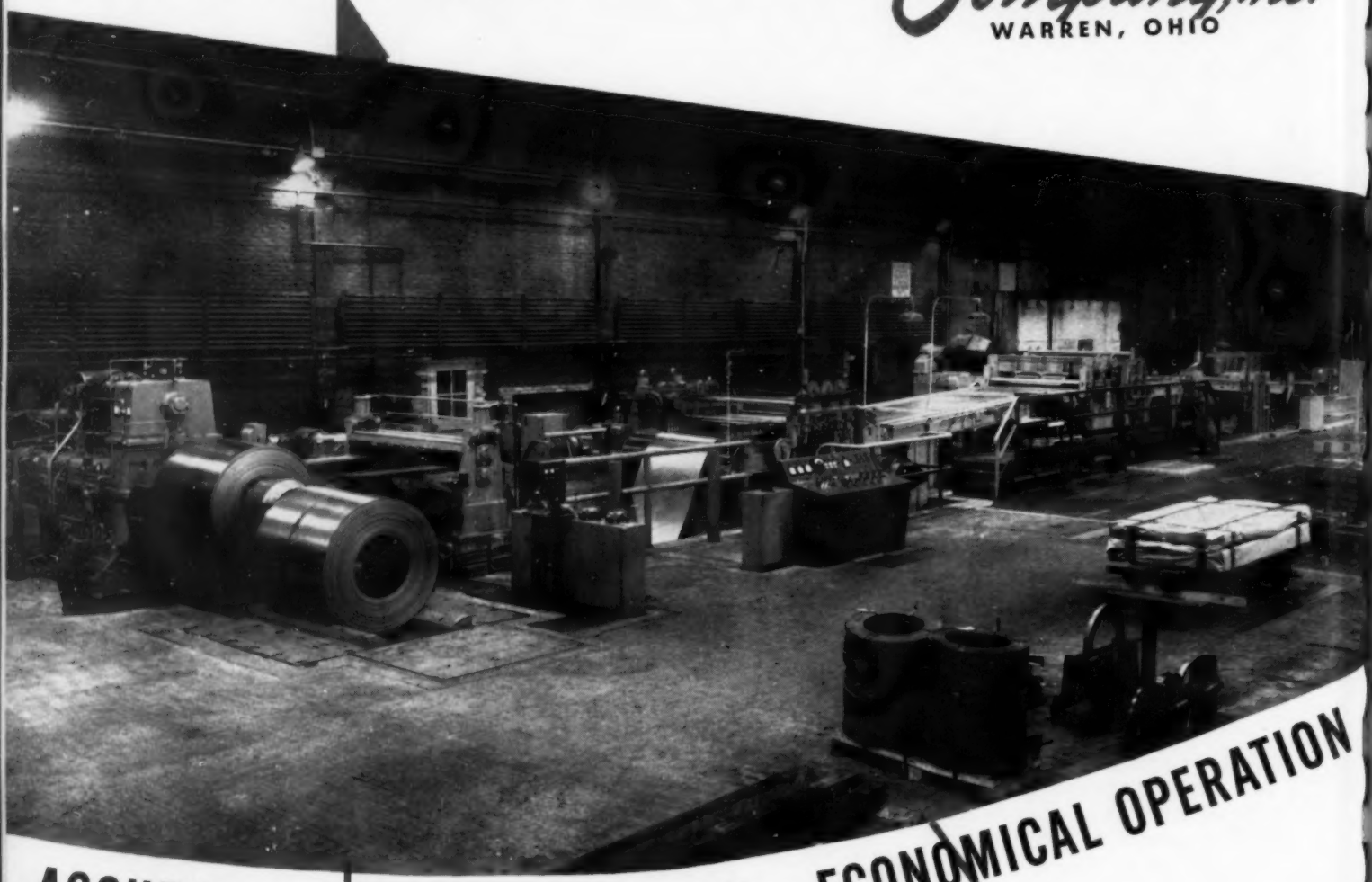

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Published Monthly by
ASSOCIATION OF IRON AND STEEL ENGINEERS
1010 EMPIRE BUILDING
PITTSBURGH 22, PENNSYLVANIA

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Indexed by Engineering Index and by Industrial Arts Index.

Single Copy Foreign Prepaid $2.00 (U. S. funds) Single Copy $1.50
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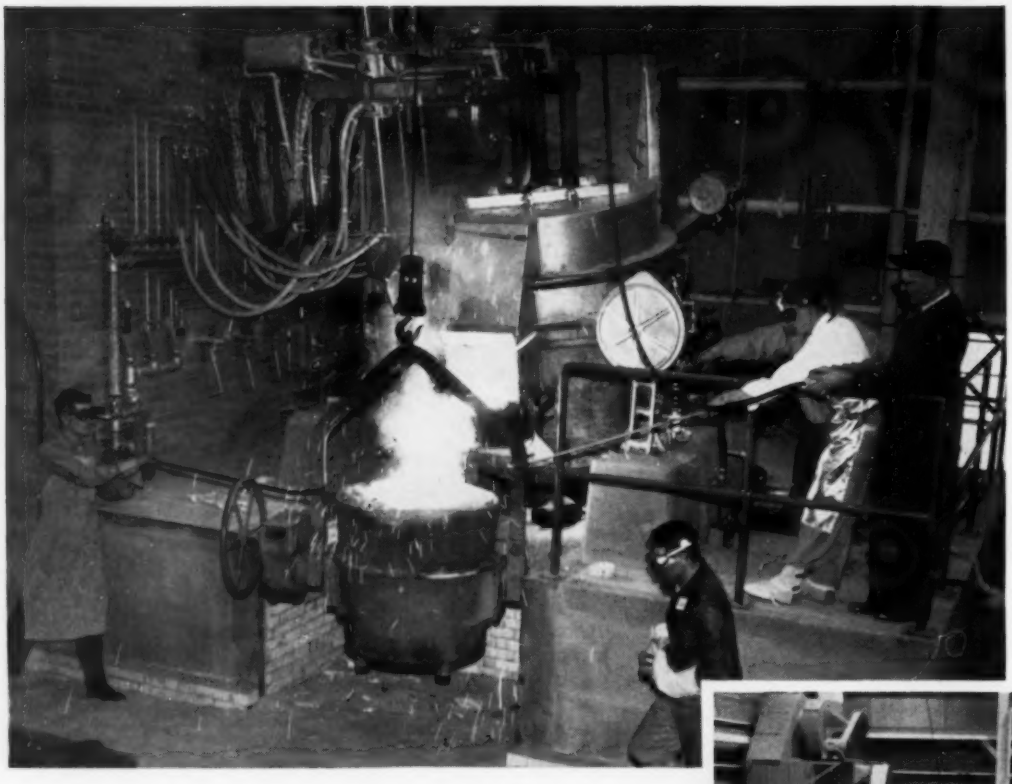

● Scientists, laboratory assistants and skilled operators work side by side to develop methods and materials at General Electric's new Metals and Ceramics Laboratory.

1-ton heats in this Lectromelt* furnace shorten the step from research to production

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MOORE RAPID

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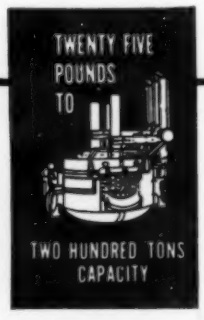

Figure 1 — The Monessen plant is located in a bend on the Monongahela River.

Pittsburgh Steel's new hot and cold strip mill at Allenport, Pa.

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. . . . the addition of flat rolling mills by Pittsburgh Steel has reduced fluctuation in the company's operations . . . . a much more satisfactory product mix has been obtained which should result in more profitable operations . . . .

▲ THE Pittsburgh Steel Co. started operations at Monessen, Pa. about the beginning of the century with a small plant which included one rod mill, wire drawing benches and equipment for producing nails and fence. In 1950 the company was operating three blast furnaces, 12 open hearth furnaces, blooming mill, bar mills, two rod mills, wire mill and complete departments for producing fence and fabric. About this time the company was also operating four seamless tube mills at the Allenport plant which is located a few miles south on the Monongahela river. The principal products being produced in 1950 were semi-finished steel items, wire, wire products, such as concrete reinforcing, fabric, fence, nails, seamless steel tubes and tubular products.

This product mix was not satisfactory as the company's operations were subject to wide fluctuations. In 1950 the decision was made to increase the range of the company's operation by entering the flat roll market and the first step of this program was taken when contracts were let for the purchase and installation of a high-lift, slabbing-blooming mill. In early 1951 contracts were placed for the purchase and installation of the strip mill. Balancing existing ingot production against the projected requirements for the proposed sheet mill necessitated changes in the steel plant at Monessen. New turboblowers were installed at the blast furnaces and many changes were made at the open hearth to increase the size of heats that could be tapped and to provide the necessary equipment to handle the large heats. Soaking pit capacity was increased by the addition of new blocks of pits. As space in the

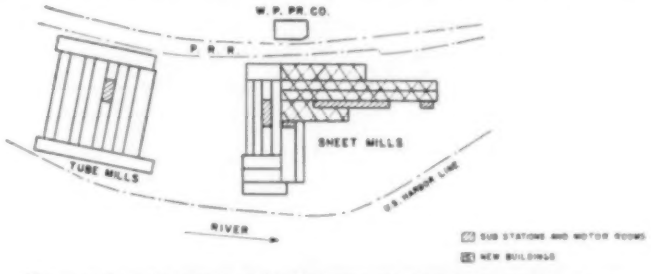


Figure 2 — Layout of buildings at the Allenport plant.

soaking pit area is very limited, it was necessary to remove some of the old blocks and replace these with larger pits in order to accon.plish the overall objective of providing increased soaking pit capacity. The existing 3-high steam driven blooming mill was replaced by a 46-in. reversing mill including a slab piler, crop shear and ingot buggy. Figure 1 shows the Monessen plant.

A study of proposed locations for the strip mill indicated the Allenport plant site offered most advantages,

but the problem became involved with a proposal to discontinue operation of the pilger seamless tube mill. The final decision was to abandon the pilger mill and to utilize the buildings it occupied and construct such additional buildings as would be required to house the sheet mill facilities. The arrangement of the buildings at the Allenport plant is shown by Figure 2. Note the remaining seamless tube mills are located upriver or at the left side of the drawing, the sheet mills are located down-river or at the right side. The unshaded portion of the sheet mill buildings are those that were in existence at the beginning of this project. The shaded areas are new buildings that were added.

Figure 3 shows the Allenport plant and the arrangement of the buildings in relation to the river, the Pennsylvania railroad and the highway. Note the old or existing buildings are located crossways on the land and therefore, it was not practical to lengthen these buildings sufficiently to accommodate the hot strip mill. However, it was quite practical to utilize these existing buildings to accommodate the proposed cold roll facilities and plans were made accordingly.

The new buildings in the hot mill group have a maximum length of approximately 1200 ft and vary in width from 50 to 118 ft, center-to-center of columns. Normal column spacing is 25 ft, the elevation from mill floor to crane rail is 35 ft and from bottom chord of roof truss to mill floor is 47 ft. Operations were continued in the pilger seamless tube mill until November, 1952. At this time the mill was dismantled and the buildings altered for the cold sheet mill operations. These alterations were rather extensive as the buildings were originally designed for 7½-ton overhead cranes while the new cranes in some cases had capacities up to 60 tons. In most cases, crane girders were replaced while it was found practical to reinforce the existing columns sufficiently to carry the increased loads.

The question of replacing the existing column foundations was resolved by running soil tests from which it was determined the safe bearing loads could be increased 50 to 75 per cent over the original design. This permitted utilizing the existing column foundations except in those few cases where excavation for adjacent foundations made their removal necessary.

The existing tube mill plant services were not adequate for the proposed installation and were replaced or expanded to meet the new requirements.

Two centrifugal pumps, each rated 20,000,000 gallons per day were installed; one pump being motor driven and the other steam driven. These were located in the existing power house in the space formerly occupied by the condensers of two turbogenerators which had been dismantled. This location permitted the reuse of intakes and traveling screens formerly used for the condensers.

Natural gas for slab heating furnaces and annealing was not available and arrangements were made with the local public utility for a new service from a main line several miles distant.

The original power supply for the plant was inadequate and a complete new sub-station was provided.

A 66-in, semi-continuous hot strip mill rated 600,000

Figure 3 — The Allenport plant offered most advantages for the new flat roll mills.

tons per year was purchased as the first step in the strip mill program. This mill was designed to produce hot rolled strip 20 to 60 in. wide, 0.060 to 0.187 in. thick with a maximum coil weight of 30,000 lb or 500 lb per in. of width. The mill includes two slab heating furnaces, a 2-high roughing scale breaker, a 4-high reversing rougher, four stands of a projected 6-stand finishing train and one down-coiler. This seemed adequate for the projected tonnage, but provisions were made for additional furnace capacity, two future finishing stands and a second coiler. Figure 4 shows the general layout of the hot strip mill.

Slabs from the blooming mill at Monessen are transferred to the Allenport plant by river. They are unloaded at the dock and moved to the slab yard by rail. The slab yard includes the usual storage area, scale pit and scarfing beds. Slabs are routed from storage to inspection, scarfing and furnace charging or those which have been previously conditioned at the Monessen plant are charged directly to the furnaces from storage. Each slab furnace is equipped with a magazine depiler from which the slabs are pushed through the furnaces by double pushers. The double pusher permits charging either single or double rows through the furnaces. These depilers and pushers are powered by eight mill type motors, each rated 100 hp.

The two slab heating furnaces are triple-zone fired, and each is rated 80 tons per hour. They are arranged for either natural gas or oil firing. The effective hearth is 22 ft wide by 80 ft long. Two sets of wet skids carry the slabs through the heating zone, the normal dry skid arrangement being used in the soaking zone. The furnace controls are so arranged that the changeover from natural gas to oil firing can be made progressively. The total time required for this change is approximately 20 minutes.

The furnace delivery table is divided into two sections, each section being independently driven. The tables are equipped with the usual furnace discharge bumpers.

The 2-high scalebreaker is equipped with 36 by 66-in. rolls, the usual pinion stand, gear reducer and fly

wheel. The first descaling header is located at the discharge side of the scale breaker and is fitted with sprays operating at 1200 psi.

The table between the scale breaker and the reversing rougher is divided into four sections, each section being independently driven. The 4-high reversing rougher is equipped with rolls 36 and 49 in. diameter by 66 in. and is preceded by a vertical edger equipped with 33-in. diam rolls. Normal practice is to give each slab five passes in the rougher. The work rolls are mounted in roller bearings and the backup rolls in oil-film bearings. The second descaling station is located at the reversing rougher.

The table between the reversing rougher and the crop shear is divided into three sections, each section having its own drive. The crop shear is the drum type and may be operated manually or by a flag. Following the crop shear is the finish scale breaker which includes a pinch roll and table. Two descaling headers are provided at this location.

Provisions were made for six stands in the finishing train, although only four stands have been installed to date. Foundations and embedded conduit, etc, are in place for stands F-1 and F-6. These are 4-high stands being equipped with rolls 25 and 49 in. diam by 66 in. long and the stands are spaced at 18-ft centers. Stands 2 and 3 have gear boxes, stands 4 and 5 do not. These stands are equipped wtih the usual guides and interstand loopers. Backup rolls in the hot mill are changed by means of a "C" hook, the usual porter bar being used for the work rolls. With the present arrangement, the delivery speed of the strip from stand F-5 is 1,770 fpm which will be increased to 2,230 fpm when stand F-6 is installed.

The thickness of the finished strip is continually measured by a 100-kv, X-ray gage mounted on a motor driven carriage and located approximately 19 ft from the delivery side of future stand F-6. This location makes the gage somewhat vulnerable and it was found necessary to devise a special set of guards and guides to prevent cobbles at this point and damage to the gage.

The hot runout table is arranged in three sections and extends approximately 370 ft beyond finishing stand F-5. Each section consists of 59 rollers individually driven. Hydraulic sprays for cooling the strip to coiling temperature are mounted over the first section of this table. The sprays are operated by solenoid valves which are controlled by a load relay on finishing stand F-5. For flexibility in control of coiling temperatures, the sprays are divided into three sections with valves provided for isolating each section as required.

At the end of the hot runout table is located the mandrel type downcoiler with pinch rolls and motor driven wrapper rolls. The mandrel is 30 in. in diam and is expanded hydraulically. Pinch rolls consist of a 36-in. diam top roll and a direct driven 16-in. diam bottom roll. Wrapper rolls are arranged in four pairs. Wrapper rolls are air operated and so arranged that the coiler operator can move the rolls as a group or by individual pairs.

From the downcoiler, coils are deposited on end, on a transfer conveyor which moves them to a coiling conveyor traveling at right angles. These two conveyors have a combined length of approximately 200 ft and deliver coils to the coil storage area. Included with this equipment is a scale for automatically weighing each coil. A downender and turntable is provided for positioning the coils before being stored.

For indicating and recording slab strip temperatures, four pyrometers are located along the hot mill as follows: one at the delivery side of the scale breaker, one preceding the crop shear ahead of the finishing stands, one located between stands F-4 and F-5, and one at the downcoiler.

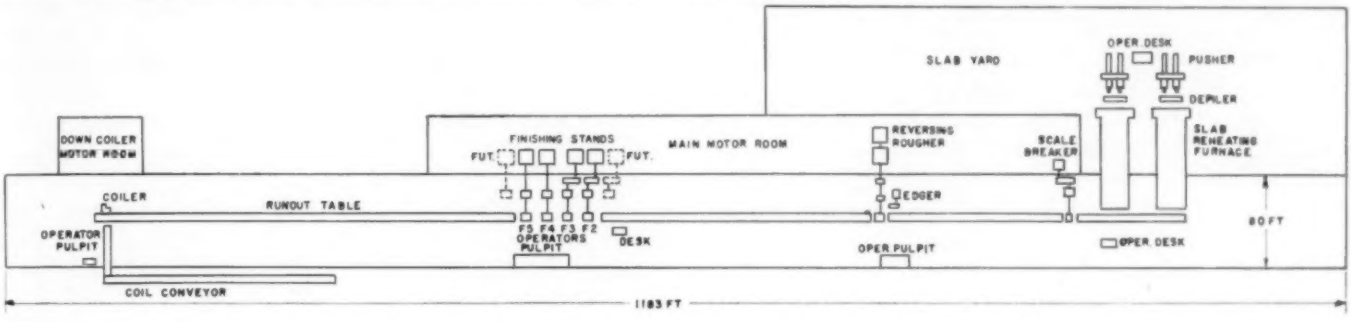


Figure 4 — General layout of 66-in. semi-continuous hot strip mill.

The usual sluiceway extends the full length of the hot mill and discharges into the scale pit. Flushing of the sluiceway is accomplished by recirculating water from the scale pit. The waste water from the scale pit is pumped to a settling and skimmer basin which in turn discharges into the main mill sewer.

Two connecting oil cellars are located in the roughing and hot finishing mill areas. In the larger cellar are located two descaling pumps. These are rated 1500 gpm each and operate at 1200 psi pressure. One pump is normally in operation while the other is in standby. The oil cellars also house the hydraulic roll balance system, the oil lubrication systems for the mill drives and the circulating oil systems for the backup roll bearings. A scrubber pump rated 800 gpm at 600 psi is located in a small basement adjacent to future finishing stand F-6.

These oil cellars are protected by an automatic flood CO_2 system from a liquid CO_2 storage tank located in the motor room basement. The same system also supplies hose reel nozzles located in the motor room as well as the acetylene-natural gas-oxygen station located in the slab yard. The hot strip mill is served by seven automatic grease systems which are located at convenient points in the hot mill buildings.

PICKLE LINE

From the hot coil storage area coils are transported to the continuous pickle line by ram truck or by overhead crane. The line includes the entry ramp, processor uncoiler, two shears, shear tables, flash welder, flash trimmer, stitcher, two looping pits, four acid tanks, two rinse tanks, side trimmer, recoiler, scale, discharge conveyor and ramp. The cascade system is employed, all makeup of water and acid is continuously proportioned and controlled by instruments. Strip is uncoiled, pickled, washed, dried, side trimmed if required and recoiled to specified weights. The maximum coil weight is 1000 lb per in. of width. The exit end of the line is arranged to permit delivery of coils to the tandem mill storage area or by means of a conveyor to the hot finishing or shipping areas. The entry end of the line has a rated speed of 1000 fpm. The pickling and delivery equipment have a capacity of 500 fpm.

TANDEM MILL

A four-stand tandem mill was installed although a considerable portion of the schedule could be produced on a three-stand mill. Since present plans include but one tandem mill and in order to permit more flexible operation of the hot mill, the four-stand mill was selected. Work rolls are 21 x 66 in. and the backups are 53 in. diam. Work rolls are equipped with roller bearings, oil-film bearings being used on the backup rolls. Sled type roll changers are provided.

The coils are received from storage by floor truck or overhead crane and deposited on the entry ramp. A coil preparation station precedes the coil box. The tension reel has a 24-in. diam collapsible mandrel. A belt wrapper is also provided.

The mill is equipped with an automatic central grease system, circulating systems for backup roll bearings, circulating lubrication system, rolling oil and palm oil systems. The rolling oil is a recirculating system as it was not permissible to waste contaminated water to the river. To date the palm oil system has been used to make up rolling oil.

In place of the conventional mill spindle couplings the dihedral type was used.

All cold mill equipment is designed to process coils 18 to 60 in. wide with a maximum weight of 1000 lb per in. of width.

4-HIGH TEMPER MILL

The four-high temper mill is equipped for processing both sheets and coils. Work rolls are 21 x 66 in. with 53-in. diam backup rolls. The work rolls are mounted on roller bearings and lubricated from a central grease system. The backup roll bearings are the oil-film type and are lubricated from a recirculating system. Coil handling equipment includes the coil preparation rolls, cone type payoff, tension reel and exit ramp. The sheet handling includes the pack tilter, entry conveyor, exit conveyor, leveller, piler and runout. The mill has a top rolling speed of 2500 fpm. An oil cellar is provided adjacent to the entry end of the mill which houses lubricating equipment for the backup roll bearings, pumps and storage tanks for the strip oiler, the hydraulic roll balance equipment and the auxiliary hydraulic pumps.

The tandem and temper mill cellars are protected by an automatic flood CO_2 system similar to that used for the hot mill. The system also supplies hose reel nozzles, the main motor-generator sets, the tandem mill, fog exhaust duct and stack.

2-HIGH TEMPER MILL

A two-high temper mill is located in the hot finish bay and is equipped for both sheets and coils. Rolls are 32 x 66 in. Coil handling equipment includes the entry ramp with coil stops, coil preparation rolls, cone type payoff, tension reel and exit ramp. The sheet handling includes the pack tilter, entry conveyor, exit conveyor, leveler, piler and runout. Each work roll is independently driven, as is the case with all the cold mill drives at Allenport. The rolls are mounted on roller bearings. The mill is equipped with the usual grease and roll balance systems.

ANNEALING

Annealing equipment consists of 12 coil annealing furnaces and 30 bases, two sheet pack annealing furnaces and six bases. Coil annealing furnaces are designed for four stacks of coils, 72 in. maximum diam and a piling height of 130 in. The furnaces are the radiant tube type. A room was provided to house the temperature recorders. Atmosphere gas is supplied by two DX machines, each having a capacity of 20,000 cu ft per hr.

The cold mill equipment was installed in existing buildings and because of the low head room in the annealing bays it was necessary to lower the working floor approximately 12 ft below normal mill floor. In order to improve ventilation in these buildings and provide air for cooling the stock, seven air intakes were constructed and equipped with fans each having a capacity of 65,000 cfm. These fans discharge through tunnels located beneath the annealing floor to the various annealing bases.

FINISHING

For cutting coils into sheets, one hot shear line and two cold shear lines were provided. The equipment in the hot shear line includes an entry ramp, processor, side trimmer, leveler, flying shear, classifier, reject piler, prime piler, scale and runout conveyor. The line can handle coils up to 60 in. wide, weighing 60,000 lb, and will cut sheets ranging in length from 3 to 30 ft. The two cold shear lines are duplicates and each includes a transfer and coil car, payoff reel, side trimmer, four-high leveler, flying shear, inspection conveyors, classifiers, prime piler, reject piler, scale and runout conveyor. These lines cut sheets 24 to 192 in. long.

A packaging line was provided to prepare sheet packs for shipment. The line is approximately 150 ft long and is made up of standard sections of gravity conveyor. Air-operated brakes are used at various stations along the line to control the movement of the sheet packs from one station to another as the pack-

aging progresses. The conveyor sections at the entry end of the line are spring mounted to reduce damage at this loading point. Special skids are provided to permit the proper placing of the strapping which is applied at a central station. Power operated tools are used and these are supported from an overhead structure.

Slitters were installed to produce the narrow strip which could not be rolled on the hot mill. The hot roll line can process the maximum size coils from the mill and slit these to widths one in. and wider. The line includes an entry ramp, coil opener, processor uncoiler, shear, slitter, recoiling reel, coil car and scrap baller.

The cold roll slitter can handle coils of 500 lb per in. of width and slit to one in. wide. This line includes an entry ramp, payoff reel, shear, slitter and recoiling mandrel. A drag generator is used to provide braking at the payoff reel. To provide for processing of coils which may be telescoped, the payoff reel was made laterally movable by means of a hydraulic cylinder which is controlled by an air jet located along the edge of the strip.

A roll shop with the usual grinders, lathe and blasting equipment was installed adjacent to the tandem mill motor room.

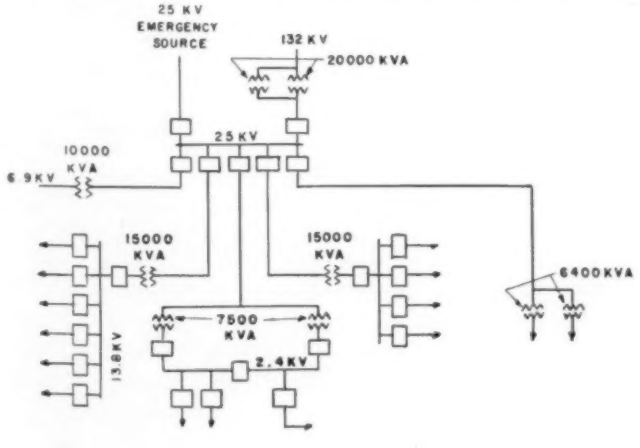
POWER SUPPLY

The large electrical load associated with the proposed new mills posed the usual power supply problems. The original power supply consisted of two old turbo-generators operated at 6900 volts, in parallel with the West Penn supply which consisted of one 25-kv line from the Charleroi substation.

Since supply was so limited it was obvious that an entirely new service was required rather than any additions to existing facilities. A complete new substation was therefore provided. It was built jointly by the West Penn Power Co. and the steel company, located across the railroad and just opposite the proposed plant load center. See Figure 2. The cross hatched sections show the motor rooms for hot and cold mills, the tube mill substation, and the sheet mill transformer yard. The new West Penn sub is shown across the tracks.

The power company provided one 132-kv line and two 20,000-kva transformers with provisions for a second line and an additional 20,000-kva transformer.

Figure 5 — An entire new electrical supply was constructed.



Power is purchased at 25 kv and comes through the metering transformers to the Pittsburgh steel bus (Figure 5). The original 25-kv line from Charleroi was retained as an emergency feed, energized but normally open at the Allenport end. Five 1,000,000-kva interrupting capacity breakers supply power from the steel company bus to the plant. These breakers are equipped with permissive switches at the substation, but are operated from the motor rooms which they supply.

The 25-kv is stepped down to 13.8 kv and 2.4 kv at the sheet mills, but the original 6900-volt system at the seamless tube division is serviced over one of the 25-kv lines through a 10,000-kva transformer located about the center of the tube mill area. All the sheet division power, except for the main drive rectifiers, passes through an outdoor packaged unit substation located midway between hot and cold mill motor rooms. This substation contains two 15,000-kva, 25/13.8-kv transformers with provision for fans to increase ratings to 25,000 kva each, and two 7500-kva 25/2.4-kv transformers connected to a double ended outdoor switching station for control of all 2500-volt power for both hot and cold mills and certain tube mill facilities in this end of the plant.

The neutral point of each 25-kv transformer is grounded through a separate stainless steel grounding resistor. Differential protection is provided for all major transformers and rotating apparatus connected to the 13.8-kv systems. Bus differential protection is also provided for all 13.8 and 2.4-kv buses and pilot wire type relaying is provided on all tie feeders.

HOT MILL

Slabs are delivered from the slab heating furnaces to the 2-high scale breaker by tables driven by two 50-hp mill type motors. The scale breaker is powered by an 800-hp, 400-rpm, wound-rotor, induction motor with 250 per cent pullout torque.

The roughing mill approach table consists of two sections each powered by a 100-hp mill motor. The front and back mill tables are each driven by two 50-hp mill type motors. The rougher is direct driven by a 6000-hp, twin drive rated 0/40/100-rpm, 600-v, 50-C rise, force-ventilated. The vertical edger is gear driven by a mill type motor rated 600-hp, 150/450-rpm, 450-v, 50-C continuous force ventilated. Both of these drives have a frequently repeated, or every slab overload rating of 225 per cent of basic speed torque and an occasionally repeated rating of 275 per cent of basic speed torque.

Power supply for rougher and edger is furnished by a five-unit, motor-generator set driven by an 8000-hp, 514-rpm, 13.2-kv, 0.8-power factor synchronous motor. The rougher is powered from three 1750-kw, 600-v generators operated in parallel with series fields cross-connected. The fifth unit is a 500-kw, 450-v, generator for the edger supply. A power factor regulator is used to automatically regulate and reduce the effect of load swings on the power system.

Rotating regulators are used for control of both rougher and edger. A six-point, forward-reverse foot operated master controls the mill and the adjustable

TABLE I

D-C Adjustable Voltage Drives
Reversing Rougher

Description	No. of motors	Motor frame	Hp	Speed range, rpm
Reversing mill approach table	2	614	100	0/485/970
Front mill table	2	610	50	0/550/1100
Back mill table	2	610	50	0/550/1100
Reversing mill screwdown	2	612	75	0/515/1030
Reversing mill feed rollers	2	608	35	0/575/1150
Reversing mill delivery tables	3	614	100	0/485/970

voltage mill tables, with a pilot generator driven by the bottom rougher motor furnishing the speed reference for the table control. Table I tabulates the adjustable voltage auxiliary drives for the rougher area. All motors are standard 600 series mill type motors, rated from zero to base speed by voltage control, with a two-to-one range by field control. Approach tables are driven by two 100-hp motors. Front and back mill tables each by two 50-hp, screwdowns two 50-hp, mill feed rollers each 35 hp, and delivery tables by three 100-hp motors.

From the rougher the bar is cropped on the flying crop shear which is gear driven by a 150-hp, 460-rpm, shuntwound mill type motor and passes through the finishing scale breaker. This breaker is driven by a 35-hp mill type motor, force-ventilated, 575/865-rpm, 230-v, d-c suitable for double voltage operation at double rated speed and horsepower.

HOT FINISHING MILL

Table II lists the present and future finishing stand drives. All the present stand drives are rated 4000 hp with base speed of 150 on gear driven stands No. 2 and 3, 110 rpm on stand No. 4, and 135 rpm on stand No. 5. Present plans call for 3500-hp, 150/342 rpm motors for future stands No. 1 and 6.

TABLE II

Finishing Stand Drives

Stand	Hp	Speed, rpm	Gear Ratio	Mill speed, fpm
Future F-1	3500	150/342	5.6/1	175/400
F-2	4000	150/336	3.17/1	310/695
F-3	4000	150/330	1.90/1	516/1032
F-4	4000	110/220	Direct	720/1440
F-5	4000	135/270	Direct	885/1770
Future F-6	3500	150/342	Direct	980/2230

Interstand loopers are driven by torque motors rated 235 ft-lb stalled torque, 75-C rise, continuous totally-enclosed, non-ventilated, 230-v, d-c shuntwound.

The main drive motors for the finishing train are powered entirely by mercury arc rectifiers controlled by magnetic amplifier type regulators. The mill normally operates at 600 volts on the main bus, but voltage can be varied from zero to maximum by phase shift control for starting the mill, and can operate continuously down to 450-v, if desired. The phase shift control for starting the mill is obtained by operating a master rheostat in the control pulpit. The voltage regulator, current balance, phase shift and excitation circuits are all completely static and tubeless.

Power supply transformers and commutating reactors are installed outdoors adjacent to the rectifiers. Incoming voltage of 25 kv is stepped down to 620-v, by two 6400-kva transformers with double wye connected secondaries. Arcback protection is provided by high speed automatic reclosing anode air circuit breakers. These are 3-pole breakers with each pole independently trip-free so a single pole can open without disturbing the other poles. All poles may be tripped simultaneously from a control switch, and the control switch or the automatic reclosing relay will close all poles or as many as may be open at the time. These breakers are rated 1600 amp at 850 volts.

The main 600-v power bus and associated switching elements are located in the motor room basement. Bus work is braced to withstand a short circuit current of one million amp. Because of the high rate of rise of fault current from the rectifiers, the protection of this system required a considerable amount of equipment. Since fast interruption of fault currents may cause flashover due to the inductive circuit of the machine in question, and semi-high speed breakers may allow excessive current, a combination of the two types of breakers was used. A high speed breaker in the positive side of the line was shunted by a surge protective resistor which is inserted when the high speed breaker opens. The semi-high speed breaker in the other side of the line is then opened, and the two-step interruption serves to keep both current and voltage surges within reasonable limits.

The high speed breakers were provided with bidirectional tripping so as not only to protect the motors from internal faults but to prevent excessive contribution to an external fault.

The hot run tables are arranged in three sections of 59 rollers each, individually driven by 3-hp, 750-rpm, 250-v, shunt-wound mill type motors, totally enclosed, non-ventilated, suitable for operating up to 975 rpm by voltage control.

Protection of individual motors is provided by metal enclosed control panels arranged in groups of 12 located on the main floor along the wall opposite the tables. These panels contain thermal overload breakers, field loss relays, field adjusting resistors and disconnecting knife switches. A pilot generator driven by the last finishing stand motor provides speed matching for these tables and the downcoiler. Each table section is supplied from a 200-kw generator, these forming part of the coiler motor-generator set.

DOWNCOILER

The mandrel type downcoiler is driven by a mill type motor, rated 300-hp, 375/1050-rpm, 230-v, d-c shuntwound, 75-C, force-ventilated by a motor mounted blower. Pinch rolls are each driven by a 75-hp, mill type motor. Wrapper rolls are arranged in four pairs, each driven by a 25-hp, 0/650/1300-rpm mill type motor. Mandrel and wrapper rolls, are supplied from

a common generator rated 300-kw, 250-v, d-c, while pinch rolls are supplied from a separate 150-kw generator which is part of the same 7-unit motor-generator set.

MOTOR ROOM

The main motor room for the hot mill is 575 ft long and 50 ft wide, extending from a point opposite the slab furnaces to the first section of the runout table. In general, the major rotating apparatus, switchgear, 480-v, a-c, and 250-v, d-c unit substations, control panel and rectifier are located on the main floor. The rectifier transformers and commutating reactors are located outdoors. Figure 6 shows the general layout. At the south end there is a 440-v, a-c control center for the slab furnaces, and the constant potential control for the furnace pusher, depilers and entry and auxiliary drives. Next comes the 13.8-kv switchgear, which includes the incoming line, cold mill tie, starting equipment for the 8000-hp synchronous motor and several feeder sections.

The rougher motor-generator set, main drive motors and control, and the auxiliary motor-generator sets form the next group, with the finishing stand drives and rectifiers at the north end. At the extreme end of the building are the make-up air intakes.

Between the auxiliary motor-generator sets and the rectifiers there is a 1500-kw, 250-v, d-c pumpless mercury arc rectifier supplied from the 13.8-kv switchgear. This rectifier, with its accompanying metal clad switchboard, supplies all the constant potential drives for hot strip mill, pickle line and hot finishing lines and all cranes in this area.

A 1500-kva, 13.8/480-volt unit substation located next to the rectifier supplies the various control centers for the a-c auxiliaries.

The main motor room basement contains the secondary control for the 800-hp scalebreaker motor, neutral reactor and field compartment for the 8000-hp synchronous motor driving the rougher motor-generator set, and the motor, generator and rectifier breaker panels, and motor-operated rheostats for all the rougher, edger and finishing stand drives. Space in this basement not otherwise occupied, is used for storage of spare parts, coils, etc.

A separate downcoiler motor room, 50 ft x 75 ft, houses the 7-unit 1250-kw, motor-generator set, coiler and runout table control, exciter sets and a 440-v, a-c control center.

The motor room ventilating system is arranged so that the basement is completely open to the main floor, with no air locks on the stairways. Control equipment and bus work in the basement is located in the open air areas, with individual plenum chambers and air locks around each of the foundations for equipment requiring ventilation.

Makeup air is brought into the basement through a self-cleaning precipitator and oil type air filter. Downdraft recirculating ventilation fans and water cooled surface coolers are used to ventilate all main drive motors and motor-generator sets. Non-recirculating updraft fans pull air from the basement to supply the ventilating requirements of the adjustable voltage mill auxiliary drives, edger motor and the large a-c pump motors located in the oil cellars. In addition there are two fans to circulate air between basement and main floor.

The downcoiler motor room has a similar recirculating ventilating system for supplying the air requirements of the coiler motor-generator set.

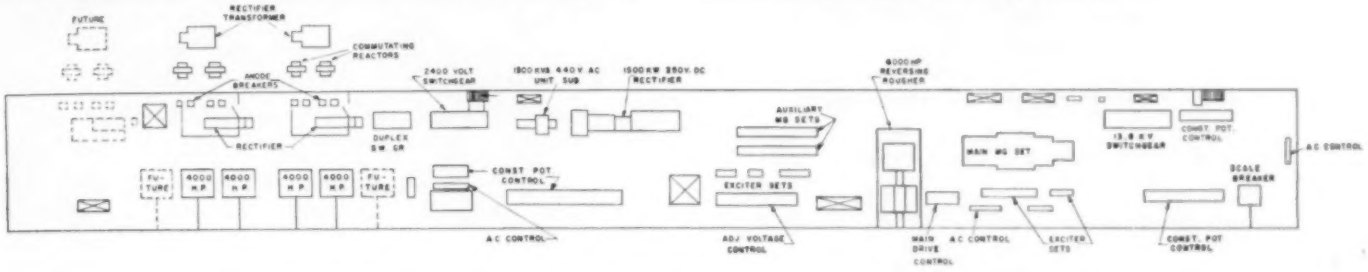


Figure 6 — Layout of main motor room for 66-in., semi-continuous hot strip mill.

OIL CELLARS

A scrubber pump and two descaling pumps, located in the rougher oil cellar, are driven by a 400-hp and two 1500-hp, 1800-rpm, 2300-v motors which are ventilated through ducts from the hot mill motor room basement. Pumps for hydraulic roll balance, grease and oil lubrication systems located in the oil cellars are all powered by 440-v motors. Control for all of these motors is located in the main motor room.

PICKLE LINE

The pickle line is equipped with a conventional flash welder supplied with 440-v power from a separate 667-kva single-phase transformer. Most of the drives for this line are adjustable-voltage d-c, supplied by two 500-hp motor-generator sets located in control houses near the entry and delivery ends of the line. Motor-generator sets and a-c switchgear are installed on the ground floor and d-c control on the second floor of these houses. Total connected horsepower of this line is 1370.

2-HIGH TEMPER MILL

This mill is driven by a twin 500-hp, 250-v motor with a 400-hp motor driving the reel. The payoff reel drag generators are rated 75 kw each. Power is furnished by a five-unit motor-generator set driven by a 1000-hp, 2300-v synchronous motor. A buck-boost system is used, controlled by rotating regulators. Connected horsepower totals 1400 for this unit.

Motor-generator set and drives located on mill floor

are force ventilated by filtered air from the basement control room in which all control equipment, fans and air filters are located.

HOT SHEAR LINE

This line is an adjustable voltage line supplied by a three-unit motor-generator set driven by a 700-hp, 2300-v synchronous motor. Control and motor-generator sets are located in the pickle line entry end control house. This line has a total of 680 connected horsepower.

TANDEM MILL

This mill is the first to use twin motor drives on all stands. The selection of the same horsepower ratings on the last three stands is a trend in the powering of recent 4-stand mills. The gear ratios, Figure 7 were were chosen to permit duplication of speeds as well as horsepower for these stands.

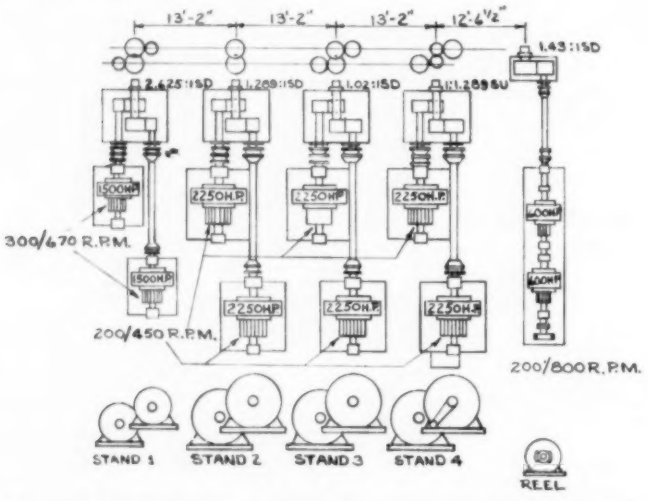


Figure 7 — Schematic general arrangement of electrical arrangements for four-stand tandem cold mill.

Each pair of 2250-hp motors is supplied by a 3600-kw generator while the two 1500-hp motors driving the first stand are powered by a 2400-kw generator. These, together with a 1000-kw reel generator, are driven by 10,000-hp, 360-rpm, 13.2-kv synchronous motors having a common automatic power factor regulator.

Control of all stands and reel is provided with 400-cycle magnetic amplifier regulating equipment. A separate magnetic amplifier cabinet is used for each stand, the reel and the 400-cycle generator. These cabinets are ventilated with air from the main motor room cooling and recirculating system. Like the main motors, the cabinets and amplifier components are duplicates for all stands. The use of the magnetic amplifier regulating system has resulted in excellent mill performance, particularly during threading, accelerating and decelerating.

A brief review of the arrangement of the motor room may be of interest. Figure 8 shows the very low head room, as well as some of the ceiling and lighting details. This motor room was located about the middle

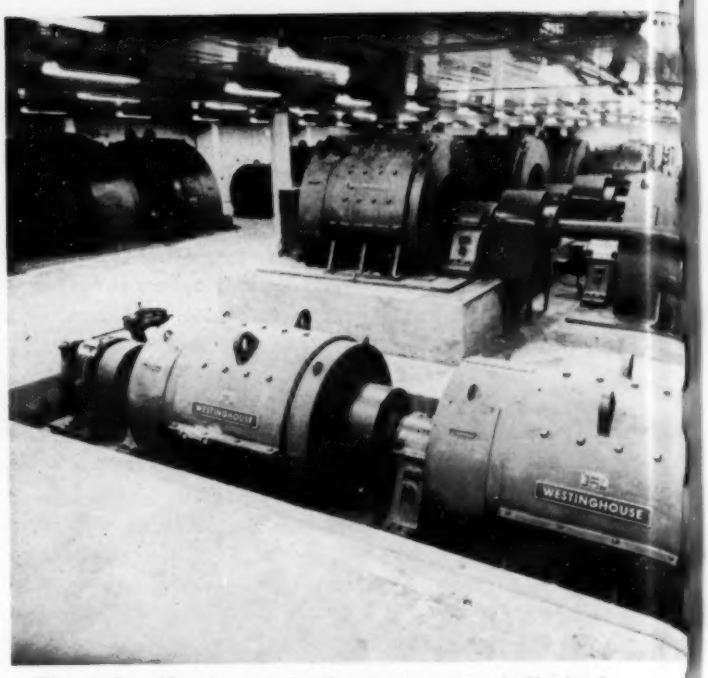


Figure 8 — Head room in the motor room is limited.

of an existing building, with crane rails only 23 ft-6 in. above the floor. One end contains the roll shop and the remainder is used principally for coil storage. To permit use of the 60-ton crane at either end of the building, the motor room height was restricted to 11 ft. In order to make the same crane available for lifts in the motor room, the roof was made removable. It consists of steel decking with overlapping joints, fastened down only sufficiently to withstand the slight air pressure in the room. Lighting fixtures are also removable, and are mounted on channels bolted to the ceiling and are plugged into receptacles mounted on the columns.

Figure 9 shows the location of the equipment. Like the hot mill motor room, this room also contains part of the power supply equipment for the cold mill area. The 13.8-kv gear is located in the northeast corner and includes starting equipment for the cold mill motor-generator sets and the 4-high temper mill motor-generator set, three feeders and the hot mill tie line.

A 1500-kw pumpless rectifier, duplicating the unit at the hot mill, supplies 250-v power for this area, as well as an emergency tie to the seamless tube mills. The adjoining unit is a 1500-kva unit transformer station supplying cold mill auxiliaries.

Downdraft recirculating ventilation is employed, with air-to-water heat exchangers located in the basement. The arrangement is similar to the system used in the hot mill, with air locks between the basement and plenum chambers in the foundations. Makeup air is brought in through semi-automatic precipitator type air cleaners located in the southeast corner of the main floor.

Auxiliary drives for the tandem mill are all constant potential d-c or 440-v, a-c controlled from panels and load centers located on the main floor, while main drive motor and generator breakers are located in the basement. Connected horsepower totals are as follows: main drives and reels, 17,700 hp; 250-v, d-c, 485 hp; and 440 v, a-c, 1512 hp.

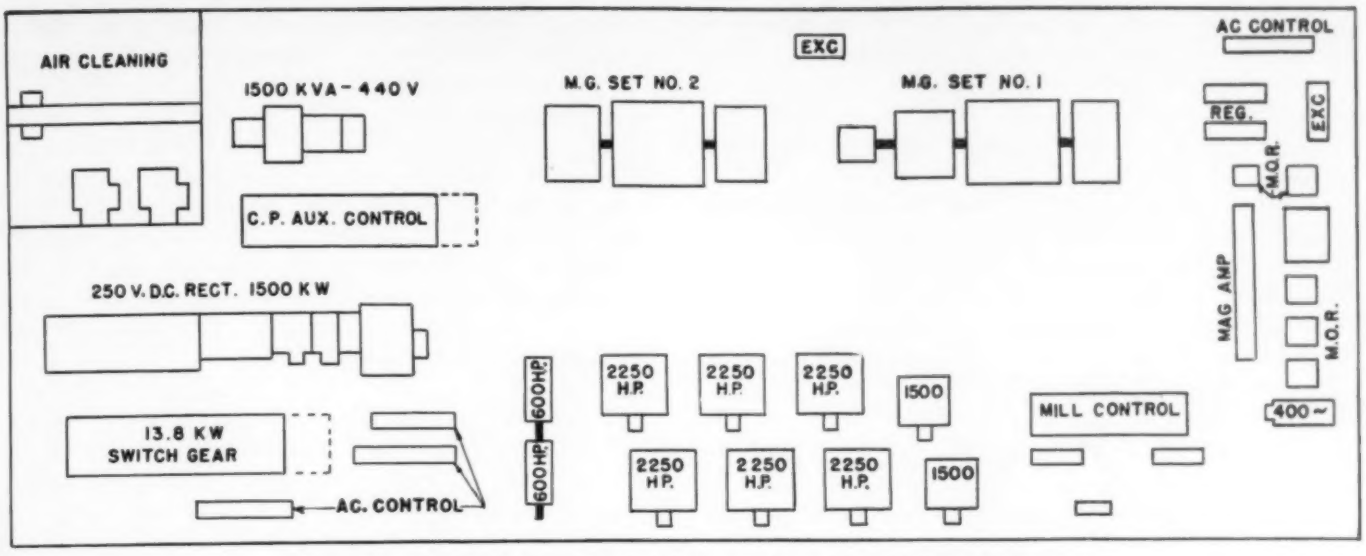


Figure 9 — General arrangement of 4-stand tandem mill motor room.

4-HIGH TEMPER MILL

This temper mill is powered by a 1000-hp twin drive, consisting of two 500-hp, 450/900 rpm, 600-v, 40-C rise force-ventilated motors, separately excited from 250 volts. Tension reel is driven by a 1200-hp, double-armature motor, rated 200/700-rpm, 600-v, which consists of two 600-hp, 300-v units, force-ventilated and separately excited from 250-v. The payoff reel drag generators are each rated 100 kw, 300/1200-rpm, 600-v, force-ventilated by motor mounted blowers and filters.

Power for this mill is furnished by a five unit, motor-generator set consisting of a 2850-hp, 13.2-kv synchronous motor, a 200-kw payoff reel generator, a 1000-kw tension reel generator, an 800-kw main drive generator and a 50-kw constant potential exciter. Filtered air from the control room basement furnishes updraft non-recirculating ventilation for all units except the drag generators.

The control house, located adjacent to the mill, houses all a-c and d-c control, rotating type regulators and exciters, and the air filters. Total connected hp for this mill is 2818.

COLD SHEAR LINES

The two shear lines are adjustable voltage lines, each with a total connected horsepower of 365, powered by six-unit motor-generator sets driven by 440-v induction motors. Photoelectric loop control is provided at each of the two looping pits, and contact type thickness gages are used to operate reject gates ahead of the pilers. Motor-generator sets are located on mill floor and control is housed in elevated control rooms.

SLITTER AND RECOIL LINE

The adjustable voltage slitter line has a total of 392 connected horsepower. It is controlled by rotating type regulators and powered by a 250-hp motor-generator set. Tension is adjustable and is maintained by a tachometer generator driven by one of the idler rolls. Control and motor-generator sets and exciters are located in a control room at floor level.

ANNEALING DEPARTMENT

Air for the annealing furnaces is supplied by blowers driven by two 75-hp and seven 25-hp, 440-v motors. There are four 7½-hp vertical fan motors on each base, or a total of 100 for the department. Power is supplied through a transfer switch from either of two 1500-kva substations.

CRANES

Crane service for the strip mill is furnished by the original tube mill cranes, supplemented by a number of new ones. The present total for the division is one 5-ton, four 7½-ton, one 10-ton, two 20-ton with 5-ton auxiliary, five 30-ton, four 40-ton with 15-ton auxiliaries, and five 60-ton, four of which have 15-ton or 25-ton auxiliaries.

SUMMARY

It is now in order to measure the degree to which the objective was reached.

Figure 10 — The addition of the new facilities means that practically all steel produced is shipped as a finished product.

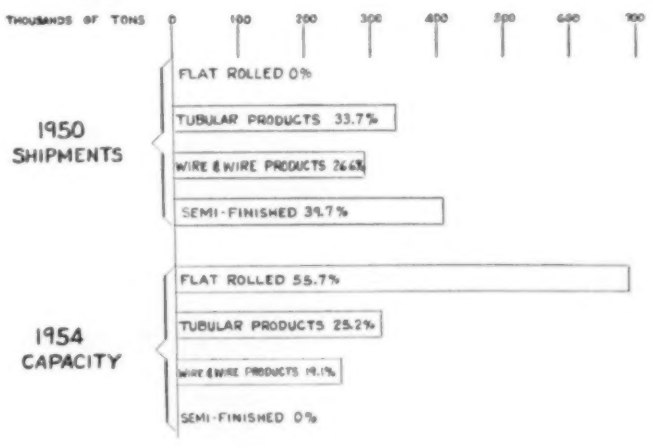


Figure 10 shows Pittsburgh's 1950 shipments compared with present capacity. Semi-finished products, mainly ingots and blooms accounted for almost 40 per cent of the total in 1950, tubular products 33.7 per cent and wire products 26.6 per cent, with no flat rolled shipments.

With the completion of the cold rolling and finishing equipment in 1954, the product mix has changed as indicated in the lower part of the chart.

Flat rolled steel now accounts for 56 per cent of the total, tubular products 25 per cent, wire and wire products 19 per cent with practically no capacity available for semi-finished products.

It is believed this product mix fits the market much better and should result in a more favorable operating rate.

DISCUSSION

PRESENTED BY

S. C. READ, Director, Construction and Maintenance, Jones and Laughlin Steel Corp., Pittsburgh, Pa.

H. A. LONG, Chief Engineer, Pittsburgh Steel Co., Allenport, Pa.

A. F. KENYON, Steel Mill Engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.

S. C. Read: Mr. Long mentioned they had a coil scale on the conveyor from the coilers. What type of a scale was selected?

H. A. Long: The scale selected for the conveyor was the conventional platform type, lever and fulcrum scale mechanism.

A. F. Kenyon: Mr. Long and Mr. Peth are to be congratulated for the very fine and complete description of the new hot and cold strip mills at Allenport, and it must be a real satisfaction to them and to their company that this major expansion project has gone into service so smoothly and worked out so successfully.

Mr. Peth commented that they had pretty much adopted proven conservative designs and had tried to avoid too much pioneering. Actually, however, I think they have quite a few new features in both the hot and cold mills, and I believe that most of these have proven quite successful.

The tandem cold reduction mill has a twin-motor for the separate drive of the upper and lower working rolls on all four stands, also twin-motor drives were used for both the four-high and the two-high temper pass mills. Twin motors have been used for the last two or three stands of several four-stand and five-stand tandem mills, however, this is the first large tandem cold mill to make use of twin-motor drives on all stands.

The tandem cold strip mill makes use of completely new regulating systems for controlling the individual stand supply generators, and the winding reel motor and its supply generator. These new regulating systems utilize static magnetic amplifier regulators, eliminating many of the previously used rotating regulators and exciters, and achieving faster response, increased stability, and lower maintenance. This regulating system was described in a paper "Operation of Magnetic Amplifier Controlled Tandem Mills" presented by Messrs. Peth and J. W. Brinks. See June 1955 Iron and Steel Engineer.

I would like to comment on one feature of the rectifiers for the main power supply to the hot strip finishing mill. The use of ignitron mercury arc rectifiers for the 600 to 750-volt, d-c main power supply for continuous running mills has become quite common, because of their advantages of lower first cost, higher operating efficiency, simpler foundations, less ventilation equipment, etc. At the Allenport installation, the rectifier power transformers are energized directly from the 25,000-volt utility supply, thus effecting further savings in first cost and operating losses. It is not practicable to operate motor-generator sets at higher than 13,800 volts, whereas it is entirely feasible to operate large rectifier power transformers at 34,500 or higher voltages. Thus rectifiers may have the added advantage of eliminating the intermediate voltage transformation. At least one other hot strip mill installation has been made with the rectifiers operating directly from the 30-kv supply voltage.

1956 AISE SPRING CONFERENCE

April 30, May 1, 2

Lord Baltimore Hotel Baltimore, Md.

By GEORGE E. DUERR
Industrial Sales Manager
West Penn Power Co.
Pittsburgh, Pa.

Problems in Supplying Power to electric furnaces

. . . . the problem of serving arc furnace loads is not insurmountable . . . . essential for an economical solution is early planning by both the utility and the steel plant engineer to make sure that adequate and economical arrangements can be made for handling the power required . . . . proper design helps in meeting the high peak loads and also in reducing load swings . . . . proper selection of equipment will also improve power factors . . . .

▲SOME steel mill engineers have probably had experiences which lead them to feel that power companies are reluctant to serve electric arc furnace loads. At times there is reluctance and the major reasons why this is so are:

1. The load characteristics of the arc furnace are very ragged. For example, (Figure 1) is a chart for a 70-ton arc furnace. Note that it can and does swing from 0 to 15,000 kw putting rapid changes in load on the utility's system. In a large furnace shop, swings such as these keep a utility in hot water. Load dispatchers who are responsible for putting on and taking off generators to match the load have difficulty in operating the system in the most economical manner and in anticipating the system requirements.
2. These ragged loads disturb system voltage. Because the utility is required to supply adequate voltage regulation to all of its customers, it is very conscious of the loads which make this job difficult. Steady voltage is becoming more and more of a necessity as new uses such as television expand.

Figure 1 — Wide swings in power demand are indicated in this chart for a 70-ton arc furnace.

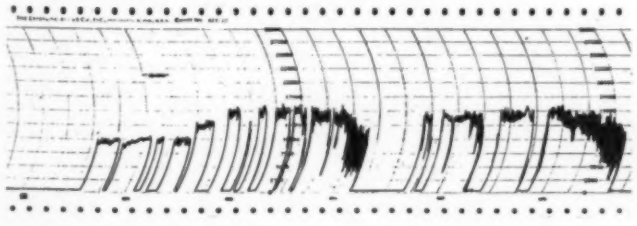


Figure 2 is a voltage chart taken at a power station bus near a steel mill. Part of the variation is caused by the heavy peaks of the mill, part by the reactive kva demanded by the load. The reactive component of a load is frequently a greater problem than the kw component. It not only creates a voltage disturbance, but also uses up generator capacity, transmission capacity, transformer capacity and complicates power station loading. In this case, the scheduled objective is to maintain 134,000 volts at the bus, as is shown on the chart by the heavy straight line. The chart shows how the voltage varies from this objective where mill loads are involved. The problem of supplying reactive capacity has been fully covered by a number of papers presented at meetings of the American Institute of Electrical Engineers over the past five or ten years, and has been reproduced in the Society's transactions. They are recommended to anyone who would like to pursue this subject further.

3. Frequently, in order to control power cost, total plant demand is limited by the steel company to some predetermined value. If arc furnaces which are easily curtailable are part of the load, they are most generally used for load control. For example, Figure 3 is a chart for part of the melting cycle of an arc furnace, where the furnace is being used to hold the 15-minute demand for the plant to a predetermined level. Notice the number of times that the furnace was dropped to hold the total demand down. If the operator is alert, this action partially accomplishes the steel company's objective. However, it creates heavy maintenance on the equip-

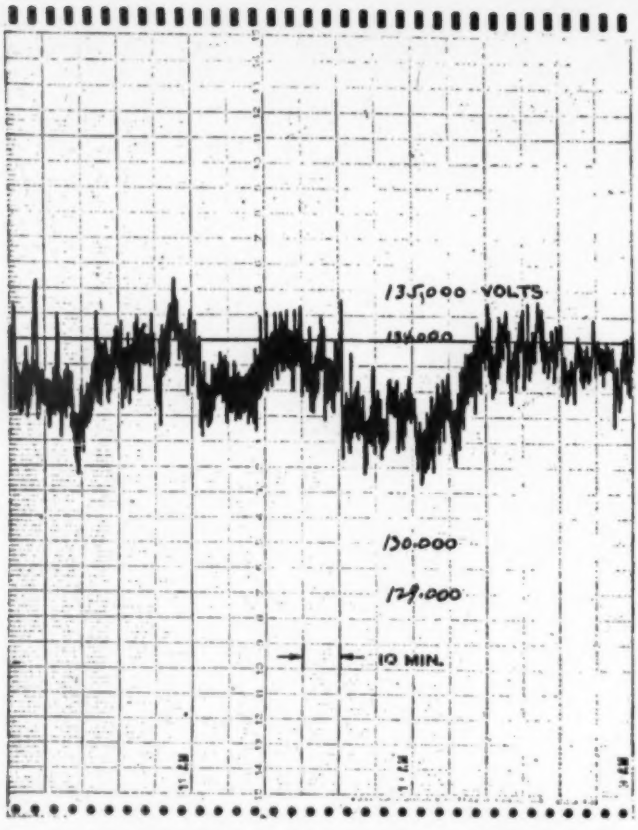


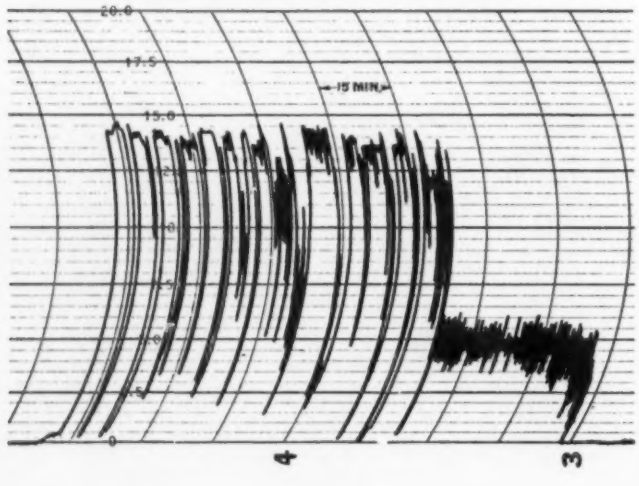
Figure 2 — Record of voltage at a power plant bus from which steel mill loads are served.

ment, and also creates problems for the utility in that the utility is required to provide the full capacity of the load and the swings create severe fluctuations which disturb the whole power system.

Fortunately, there are solutions to these problems. While the solutions will not completely eliminate the troubles, they go a long way toward alleviating them.

To begin with most of the major loads of a steel mill are very irregular. They zig up and they zag down. For example, Figure 4 is a chart which shows an operation in which a bloomer, a universal mill and a hot strip mill contribute the fluctuating loads. In this installation, a swinging load of 28,000 kw is thrown on the utility's lines. While rolling mill loads zig up and arc furnace loads zag down, both disturb the system.

Figure 3 — Record of part of the melting cycle of an arc furnace which is being used for load control.



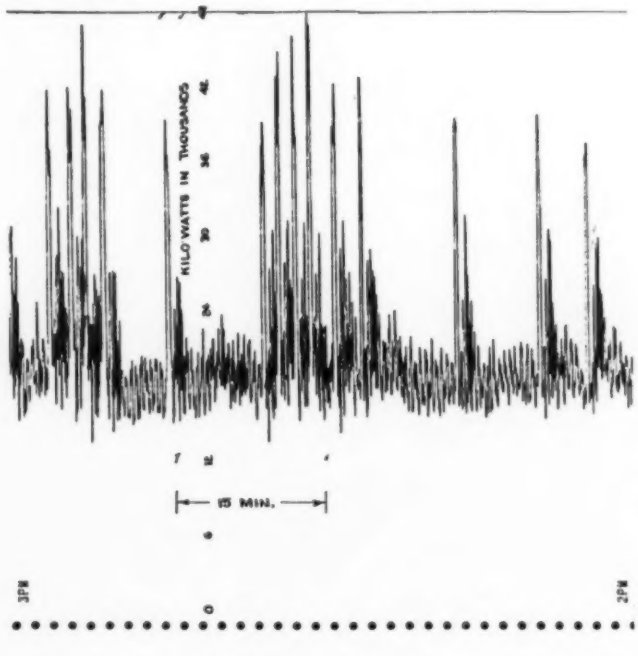
However, if all the zigs could be fitted into all of the zags, it might be possible to almost level out the load. If this could be done, both the steel company and the utility would profit. Let me take an example to illustrate this point.

This furnace of Figure 1 has a maximum power requirement of 15,000 kva. If it is working in the same shop with other furnaces of approximately the same size, some form of scheduling becomes immediately necessary if the materials handling problems of charging, pouring and patching are to be done economically. This schedule prevents all of the furnaces from melting down at the same time and tends to level the total power use of the shop. For instance, in one shop with four furnaces, the 55,000 kva of connected load shows only 37,500 kva of demand.

When this furnace load is integrated into a hot mill load such as shown in Figure 4 and is then further combined with a cold roll and finishing operation such as shown in Figure 5 the total load picture looks like that shown in Figure 6. One can still see some of the effects of the swinging loads but many of the zigs and zags are beginning to fit together. This is still a long way from a level load. However, it is definitely a step in the right direction.

At this point, one must emphasize that any mill contemplating the use of arc furnaces should carefully study the effect of such an addition to the total load. The furnace load because it is controllable, can be used to materially increase the total load factor of power use. This means that in estimating the power cost for operating a melt shop, due allowance must be made for the diversity between the melt load and the mill load, in determining the effect of the furnace load on the total demand. In the example cited, 55,000 kva of connected furnace load was involved. Of this 55,000 kva, 37,500 kva shows up as the melt shop demand and of this amount, only 24,000 kva shows up as additional billing demand because a large part of the furnace loads has been fitted into the zigs of the regular mill load. In many

Figure 4 — Chart shows effect of fluctuating loads on plant demand.



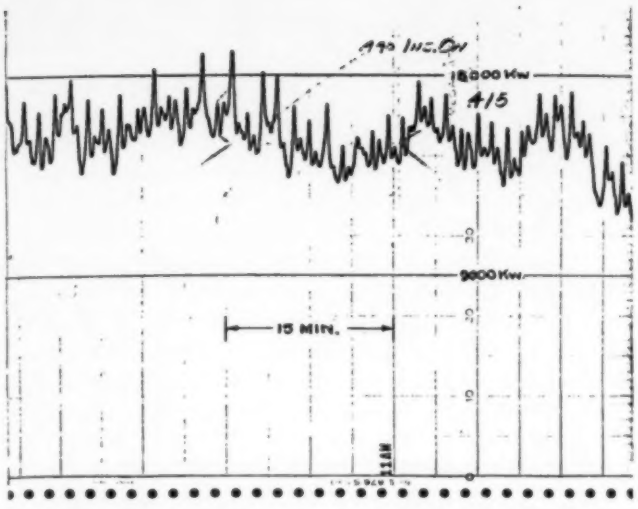


Figure 5 — Load pattern for a cold roll and finishing department shows marked fluctuations.

large mills, it should be possible to integrate a multi-furnace shop into the total load and reflect as little as 50 per cent of the connected load into the total demand.

What can be done about voltage fluctuations and reactive needs The problem becomes acute where arc furnaces are being used because of the large reactive requirement of this type of equipment.

All large power rates have power factor clauses. These clauses are necessary to compensate the utility for the reactive that it supplies. Obviously, if the mill can supply its own reactive, it can reduce its power bill.

The best place to correct power factor is at the point of power use. Frequently, the ability to improve power factor can be found right in the plant. Using fully the leading reactive capacity that is already available in synchronous equipment has the advantage that it costs little or nothing to get it. Several things that can be done are:

1. Be sure that all synchronous motors are producing their maximum output of leading reactive.
2. Consider 80 per cent leading synchronous motors for new equipments purchased or old equipments replaced.
3. Be sure that furnace operators control furnaces to achieve optimum power factor. Frequently, furnace operators think that the more current poured into the heat the better. All operators should be carefully trained to keep their power input at the optimum current level.

One plant had a reactive requirement of 30,000 kva. After doing all of these things, adjusting excitation on present synchronous equipment, providing 80 per cent leading motors on new equipment then being installed and further instructing their furnace operators, they have been able to achieve unity power factor.

Management is constantly demanding lower costs. To meet this demand some steel mills have established control systems which prevent the irregular loads from peaking together and thus creating extremely high demands. Those who have arc furnaces have found that these furnaces are useful to this control system since they can take short curtailments without material loss in output.

However, the method of controlling the furnace is

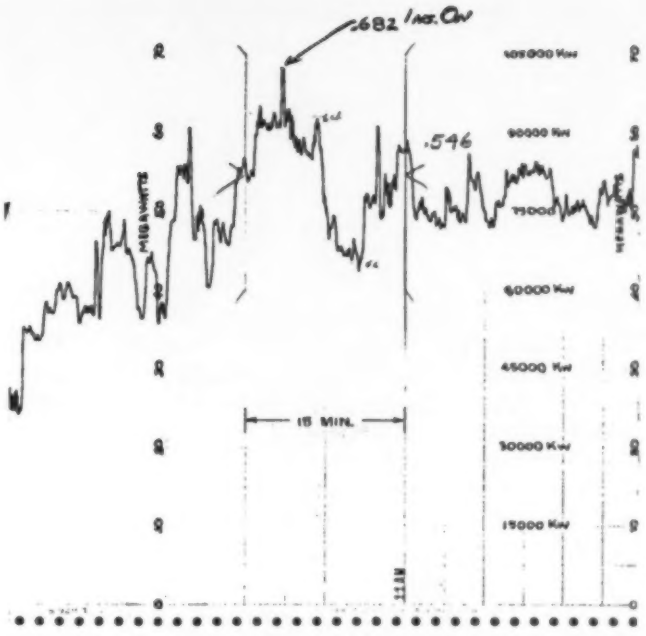
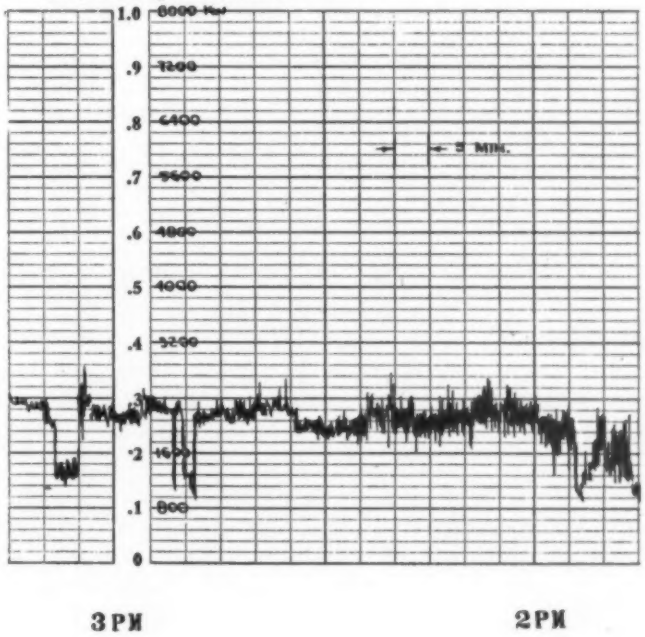


Figure 6 — Load pattern of combined furnace, hot mill, and cold mill operations shows reduction in peaks.

important. Figure 3 is for a plant where a load limiter signals the furnace operator that the demand is about to exceed a predetermined level. The operator then drops the furnace and leaves it off until the signal clears him to proceed. In the heat partially reproduced on this chart, power to this furnace was interrupted thirteen times in the 2½ hours shown. Psychologically, this type of control has a bad effect on the melter. It gives him a feeling of frustration and distracts him from other important duties. While it saves on the power bill, it creates other costs that tend to wash out some of the savings.

A better method we think is that of using automatic controls which instead of interrupting power to the furnace completely, simply cut back on the input until

Figure 7 — Load pattern of a steel mill using automatic load control devices on arc furnaces shows good uniformity in demand.



the peaks of other operations are passed. Here, for example, (Figure 7) is a chart from a small mill which has two furnaces. While the furnaces and the mill drives are relatively small as compared to the big shops, one can see very little evidence in this chart of the irregular loads that are being served. In this type of control the degree of cutback depends entirely upon the need, the melting process is not interrupted, but is reduced to a slower melting rate for short periods of time. Because such controls are automatic, they take the responsibility for the cutback out of the hands of the operator. Again, because they are automatic, they prevent overshooting the predetermined demand level which sometimes happens when signals and manual action are employed. With this type of control, steadier voltage and less maintenance cost can be achieved.

The electric furnaces if properly used can thus be a big factor in helping to smooth out the ragged power use pattern of the mill. It can help to build a good load factor for the plant — an important item in achieving low power cost. And because of the smoothing out of the load, it becomes an easier load for the power company system to handle.

Why, then, if there are at least partial solutions to these problems should utilities worry about serving steel mill loads, particularly those created by electric arc furnaces? They worry because they generally do not know enough about the new equipment that is to be installed to adequately determine the character of the load that it will produce. They are perturbed by the swinging load problem, the reactive component problem and the effect of these things on their ability to serve other customers properly. They are concerned with the problem of designing the lines and substations that may be required to serve the new load and are hampered by a lack of information as to the true load conditions that must be met.

It would then appear that what is most needed is better information. If your plans are known early enough and if we are privileged to work closely enough with you, answers to many of these worries can be developed.

All large power companies maintain staffs of competent industrial power engineers. They are experienced in power utilization work and well able to interpret steel plant needs to their company's engineering departments. They are competent to contribute to studies of load integration and control, to reactive problems and how to solve them, and they are interested in getting electric service to plants at the lowest possible cost.

Among the things that they will be interested in and can contribute to are:

1. The number of furnaces to be installed and characteristics of the transformers and controls to be used.
2. Method of operating the furnaces to achieve highest possible load factor.
3. Studies of integration of furnace loads with the other mill loads to achieve lowest over-all cost and most flexible production methods.
4. Studies of the reactive component of the load and how it can best be supplied.
5. Development of substation design and location.
6. Development of switchgear specifications that meet both the furnace requirement and the utility's short circuit capacity.
7. Interpretation of utility's rate schedule to achieve lowest possible cost.

Furnaces are getting bigger and bigger, but so are utilities. There is no reason why many of the problems of serving arc furnace loads should not get smaller. If the problems of electric service for an electric arc melt shop are approached *early* in the planning stage, if the utility has an opportunity to understand the steel company's need, and the steel company has an opportunity to see the utility's problem, this better knowledge can lead only to mutual confidence and enhancement of the possibilities for developing answers that are satisfactory to both.

DISCUSSION

PRESENTED BY

B. M. JONES, Planning Engineer, Duquesne Light Co., Pittsburgh, Pa.

A. L. HODGE, Research Metallurgist, Linde Air Products Co., Tonawanda, N. Y.

H. H. ANGEL, Electrical Engineer, Construction and Engineering Dept., Bethlehem Steel Co., Bethlehem, Pa.

GEORGE E. DUERR, Industrial Sales Manager, West Penn Power Co., Pittsburgh, Pa.

B. M. Jones: The electric characteristics of arc furnaces must be known by the power companies so that they can provide adequate electric supply and the comments of Mr. Duerr are very much in order.

In addition, we beg that steel mill people contact the power companies when they are preparing for, recommending, or even thinking about an electric arc furnace, and definitely before they get their appropriation. It is a sad state of affairs, and it makes it very hard for the power company, when the steel mill people come around for electric power after they have placed the order for equipment, which includes transformers and associated electrical apparatus, for we also have to buy transformers and electrical equipment also, and in some cases have to build a big line with rights of way troubles.

I am merely the planning engineer of our company, but it is difficult for planners when in talking to the furnace builders around town whom we know quite well, to hear them say, "The ABC Company has just placed an order for an 18-ft furnace with us." Then we hustle around and find out that the steel company has not even begun to think about buying the electricity to run this furnace. Maybe they think we can pull the rabbit out of the hat and send the line crew out any day to build the line and set the transformers. This is far from Utopia, and the designing, planning and engineering, the purchase of equipment, and obtaining of the rights of way for the big line itself take time, so again let us start the race when the steel people start.

Mr. Duerr's first sentence can be emphasized considerably, as fewer and fewer power companies are reluctant to serve electric furnace loads as the knowledge of how to tool up for such loads is becoming more and more widespread. We do not think that it is so much fear or reluctance on the part of the power companies as un-

certainty of the characteristics of the furnaces. So, again, the steel mill people should let the power company start the race when they start!

I wrote an article a few years ago, published in the 1941 AIEE Transactions, on power supply to electric arc furnaces, and since that time a number of power company engineers have come to see us when they have been threatened, sometimes at the last minute, with electric arc furnaces. These men have come from far and near. We tell them how to handle such loads and what data they need and they return home with no fear of electric arc furnaces.

Naturally the power companies expect to make money out of the electric furnace load, and are interested in obtaining it, and they will do what Mr. Duerr says to help the steel companies: scheduling, load limiting, etc.

Electric arc furnaces for steel melting have been supplied by electric utility systems since 1908, the first such on the Duquesne light system in 1908 was a small single-phase furnace at the Firth Sterling Steel Company in Glassport, Pa. This was supplied by means of an 11,000-volt line and separate engine-driven generators in the old Rankin power station on the Monongahela river at Rankin, Pa. Later, as our high voltage network grew in size and capacity in that district, this 11,000-volt line was tied in with the rest of the network there.

Duquesne Light Company is not the largest supplier of electric arc furnace load, but we do have some 240,000 to 250,000 kva of load at about 20 plants in our territory. The largest plant contains three 10,000-kva and one 18,000-kva, 3-phase electric arc furnaces. Incidentally, this plant has a load limiting schedule which has been working quite satisfactorily for a number of years. This plant started out with one 10,000-kva furnace early in 1940, a second one late in 1940, and two more 10,000-kw units a year or two later. One of these four furnaces was converted to 18,000-kva a few years ago, and the other three, we hope, will be converted soon. Before the first installation was connected, we scouted around the country obtaining all the data we could on such installations, and we actually made many oscillographic tests. Later we secured all the technical data we could find, analyzed all the test data we could lay our hands on, and determined that such load was good business for our company, so we went ahead.

Mr. Duerr's points of power factor improvement and diversification of load with other mill load are very well taken. This is a joint problem with the steel company, and we power company people feel that we are going to get more and more electric arc furnaces, and we are anxious to take them on.

Naturally, some corrective apparatus has to be provided — synchronous condensers with or without booster reactors, larger lines, series capacitors (we have a 10,000-kva capacitor on a 66-kv line), and stiffer source of supply to the customer's bus, together with adequate space at the customer's plant for all of this equipment. Remember that it takes space for our transformer as well as your transformer, and that we sometimes bring our lines in at a higher voltage than that which you have running all through your plant. You would much prefer to have your own line going through your plant, and so would we, so we would like to terminate our high voltage line on the edge of your property with adequate space for transformers, switching, lightning arresters, metering, etc., and again we beg that you contact us early enough so that we do not find your new buildings being built on the site most suitable for the power company's substation. If the supply is at a really high voltage, 69 kv or 138 kv, it takes a real amount of space, so take cognizance of this early in your furnace studies.

A. L. Hodge: In Mr. D. D. Moore and associates' report "Comparative Economics of Open Hearth and Electric Furnaces for Production of Low Carbon Steels," on expanding electric furnace capacity, it is assumed that power supply from outside electric companies would be no problem and power would always be available. But let us be more realistic (or pessimistic) based on these discussions, and assume that we must build our own power plant to supply a million-ingot-ton per year electric furnace shop. Eight 25,000-kva furnaces pulling an average load of 20,000 kva each would require about 160,000 kw capacity. At a capital cost figure for power plants of $175 per kwhr, power generating facilities would cost $28,000,000.

If we now add this cost to a capital investment cost of $15,900,000 for a million-ton electric furnace shop, we end up with a total cost of $43,900,000. One author's estimated cost for eight open hearth furnaces producing a million ingot tons per year is $26,650,000. Between these two cost figures the electric furnace shop would cost 65 per cent more than an open hearth shop. (*Editor's Note.— It is believed that Mr. Moore's study assumes electric power purchased from a utility at 9 mills which rate covers capital costs of generating plant. See 1954 Proceedings AISE, p 177*).

Let us now consider material balances for these two million-ton shops both using 50/50 hot metal charges. An open hearth requires about 6,000 pounds of materials to produce a ton of ingots, whereas an electric furnace requires only 2,463 pounds per ton. To include the materials required for power generation changes this picture drastically. With an overall generator efficiency of 25 per cent, i.e. Btu from coal to Btu at the transformer, each ton of electric furnace steel would require 500 pounds of coal at 13,000 Btu per lb and about 11,000 pounds of air for combustion (assuming 100 per cent excess air). This would increase the total materials input to the electric furnace plant to 13,963 pounds per ton of ingots or 133 per cent more than the open hearth plant.

An overall heat balance also looks interesting for these two shops. Assuming that the open hearth requires 3,500,000 Btu per ton of ingots, and that the electric furnace requires only 1,600,000 Btu appears favorable indeed for the electric process. However, if we include the 25 per cent thermal efficiency at the generator, then the electric furnace requires 6,500,000 Btu per ton of ingots. This is 57 per cent more thermal energy than the open hearth requires. This means that if the overall thermal efficiency of the open hearth is 30 per cent, the overall efficiency of an electric furnace plant, based on the above figures, is only about 16 per cent. These thermal comparisons may not seem significant to some of us and they may be viewed controversially by others,

but I am sure all of us realize the importance in preserving our natural fuel reserves for our nation's future well-being and security.

H. H. Angel: I believe there are a few users of electric furnaces who have or have attempted to keep in operation some form of a demand regulator or limiter, in order to keep the total plant demand within a certain range by cutting back a little bit on the load of one furnace or more than one furnace. That was in line with the comments of Mr. Duerr.

I know of an individual who had such a regulator available, and I believe that several are used in the Pittsburgh, Youngstown, or Canton Areas. I wonder if Mr. Duerr might have any comments on the operation of such units?

George E. Duerr: One of my figures referred to a relatively small plant with two furnaces, and the evenness of the load. That was using a control made by the gentlemen referred to by Mr. Angel. That control was put in after considerable study of the plant, and after the caution had been raised that if it interrupted the heat and got them off schedule for that reason, it might not be worthwhile.

Second, because it does not interrupt the service, but simply lifts the electrodes, the question of the effect on power factor was raised. A study finally came up with some answers which looked like it was a reasonable opportunity to try it, and the company who has installed it has been quite happy with it ever since.

Actually, they have never exceeded the demand level that they set for the plant. Now, they do adjust that controller to take into account the different schedules of operation which they encounter, but it works entirely on the furnaces, and to our knowledge has never caused them any losses in production.

I might say that there are more than just this one outfit in that field. Some of the instrument companies are also working in the same field and have done quite a lot in developing equipment that can be used for this purpose.

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Increased Steel Production from desiliconized hot metal

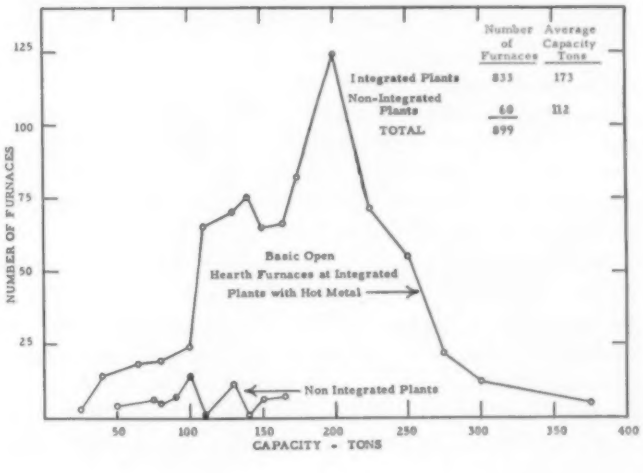
. . . . detailed analytical data presented in this paper shows that the use of a wash metal can increase production capacity at least 25 per cent for present open hearth installations . . . . analysis also shows that a desiliconized wash metal with 2 per cent carbon, 0.2 per cent manganese and 0.1 per cent silicon can practically double electric furnace output and decrease power and electrode costs by 40 to 50 per cent . . . . both practices are primarily applicable at integrated steel plants where ample hot metal is available . . . .

▲ A SURVEY of the capacities of integrated steel plants in the 1954 edition of the Iron and Steel Directory published by the American Iron and Steel Institute shows that the rated capacity of stationary open hearth furnaces in the United States is about 94,000,000 tons per year. Only integrated plants having hot metal available for the open hearth furnaces are included in this summary. The average melting rate of these furnaces is only about 15 tons of steel per hour and any method of increasing production in stationary open hearths already built would have a great effect on total annual steel production. Moreover, the capital investment in stationary open hearth furnaces is high as compared to other steelmaking equipment, and further expansion of steel capacity which is believed to be necessary will require very high investment costs if more stationary furnaces are built. Most of the increase in steel capacity since 1945 (about 30,000,000 tons) has been made by construction of stationary furnaces.

In an address before the American Iron and Steel Institute in May 1955, the president of Bethlehem Steel Company, A. B. Homer[1]*, estimated that the present steel capacity of 125,000,000 tons would have to be expanded to 185,000,000 tons by 1970 based on population growth predictions; such an increase would require new construction of 4,000,000 tons per year capacity in addition to modernization of existing capacity. Increase in raw material supply, blast furnace capacity, and steel melting furnaces would be necessary at a cost of $300 per annual ingot ton and this would approach one billion dollars per year for the next 15 years.

A statistical study of the range in size and number of open hearth furnaces in the United States shows 833 furnaces at integrated steel plants and 60 furnaces at non-integrated plants. Figure 1 shows the distribution by size based on the Iron and Steel Directory. The average capacity of all plants is 173 tons per furnace and average melting rate seems to be about 15 tons per hour depending on the ratio of hearth area to furnace

Figure 1 — The average open hearth capacity at the end of 1954 was 173 tons in integrated plants.



*Footnote — Numbers refer to bibliography at end of paper.

capacity and the percentage of hot metal in the charged mix. In recent years the tendency has been to build larger furnaces of 200 tons to 350 tons and these have a higher melting rate, exceeding 20 tons per hour in many instances. At present there are only 24 furnaces with capacities exceeding 300 tons per heat, and these are mostly operated with some form of duplexing process.

C. D. King[2] discussed open hearth capacities and melting rates in great detail in his Howe Memorial Lecture before the AIME in 1954. He showed that in 1952 the average tap-to-tap time was approximately 12 hours per heat regardless of furnace capacity, and the average melting rate per hour is 14 tons for furnaces of 170-ton capacity and 19 tons per hour for furnaces of 225-ton capacity, based on a study of 55 plants using hot metal in the charge mix.

The low output of the average size stationary open hearth furnace (170-ton) of 15 tons per hour has not been much improved by better design and construction. In addition, steady increases in the cost of labor, fuel, construction, maintenance, and capital expense have occurred in recent years. While the duplex process, using fully blown hot metal has been used for many years, only about 10 per cent of total steel output can be made by this method because of the nitrogen content of the fully blown hot metal and the complete dependence of the duplex process on blast furnace metal entirely, instead of melting large quantities of steel scrap.

It would be of great benefit to the operations of stationary furnaces to have a steelmaking process which would melt 30 to 50 per cent cold scrap with partially refined hot metal and at the same time increase furnace output, decrease slag volume and ore and limestone charges, and produce a low nitrogen steel. It is believed that this can be accomplished by the desiliconizing of hot metal with oxygen before the hot metal is charged into the stationary furnace. Less than 60 lb of oxygen per ton of normal hot metal containing 4 per cent carbon, 1 per cent silicon, and 1 per cent manganese will reduce the silicon content below 0.20 per cent and raise the temperature of the hot metal to above 2900 F. This desiliconized hot metal will be termed "wash metal" in this paper.

The open hearth furnace has a critical temperature of 2750 F which is the melting point of an iron-carbon mixture containing about 0.80 per cent carbon, the usual carbon content of the mixture of hot metal and cold scrap at the meltdown point. It is necessary to get the scrap heated above this temperature before ordinary hot metal at the mixer temperature of 2450 F can be added to the furnace. When wash metal at 2950 F is substituted for normal hot metal at 2450 F, it may be added much earlier to the furnace and the higher meltdown temperature will accelerate the ordinary oxidizing refining reactions. The partially refined wash metal not only refines more rapidly, but adds extra heat to the charge above the critical temperature, thus saving fuel and time for working the heat.

The maximum hot metal charge for stationary furnaces is under 50 per cent if a flush slag practice is to be avoided because of the large limestone and ore charge necessary for higher percentages of hot metal in the mix, and the very large slag weights which result from higher hot metal charges. On the other hand, as much as 70 per cent wash metal may be charged without developing a slag weight of over 130 lb per ton of steel. No runoff slag need be taken with such heats. Production rates are estimated to increase from 25 per cent with 50 per cent wash metal, to over 50 per cent with 70 per cent wash metal. The steel plant also becomes largely independent of outside scrap sources since home scrap will make up over 80 per cent of the cold scrap needed in the charge mix.

It is believed that a desirable desiliconizing operation with oxygen for open hearth charges is reached when the analysis of the bath reaches 3 per cent carbon, 0.20 per cent silicon and about 0.40 per cent manganese. At this stage the bath temperature is about 2950 F, and no nitrogen pickup occurs regardless of oxygen purity. If the blowing with oxygen is continued to a level of 1.5 per cent carbon and less than 0.10 per cent silicon, the temperature is so high that about 15 per cent scrap should be added to hold the bath temperature to 2950 F. The rate of blowing with oxygen greatly influences the final temperature. In addition, the turbulent carbon boil is depressed by stopping the blow at about 3 per cent carbon and dust and fume formation are decreased. Based on these considerations, all reference to wash metal used in the open hearth in this paper infer a melt of 3 per cent carbon, 0.20 per cent silicon, and 0.40 per cent manganese at a temperature of 2950 F.

The desiliconizing operation has been fully investigated in the laboratory in research work carried out in induction furnaces in order to produce high manganese slags for hot metal containing 4 to 5 per cent manganese. In this work 25 lb of pig iron containing 4 per cent carbon, 1 per cent manganese, and 1 per cent silicon were blown with oxygen. This composition was melted and held at a steady temperature of 2450 F, by balancing the power input against the heat lost in the cooling water of the induction coil, before the blowing with oxygen was begun. The rise in temperature due to the oxidation of manganese, silicon, and carbon could then be measured. It was found that the increase in temperature measured checked closely with the theoretical rise in temperature indicated by calculations. In the laboratory, the operation is striking to watch because most of the silicon and manganese are oxidized before much carbon burns. All of the oxygen reacts and no bubbling or turbulence occurs until the carbon boil begins when the silicon in the bath has been slagged. If the oxygen blowing is stopped before the carbon drops below 3 per cent the temperature of the bath does not exceed 3000 F.

A typical example of the results are shown below:

Original iron, per cent			Cu ft oxygen	Bath analysis after blowing			Slag analysis		
C	Mn	Si		C	Mn	Si	MnO	FeO	SiO_2
4.00	1.00	1.00	6.01	3.40	0.35	0.20	21.8	31.6	46.6

This work was done in a silica crucible and the oxygen was blown into the bath through a silica tube; no phosphorous reacted under these conditions and the oxygen consumption per ton of hot metal was 48.3 lb per ton. The oxygen consumption for 3.00 per cent carbon amounts to 56 lb per ton due to further oxidation of carbon and iron.

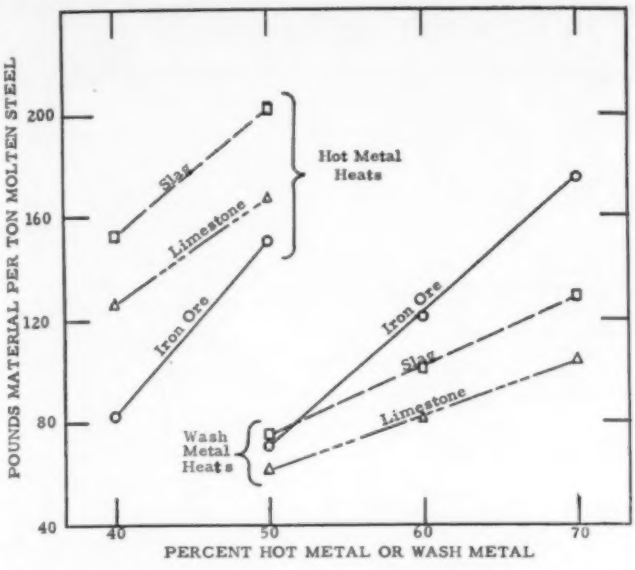


Figure 2 — Chart gives charge required in the open hearth for varying percentages of hot or wash metal.

OPEN HEARTH OPERATION

A theoretical study of the effects of this type of wash metal on production rates of stationary open hearth furnaces was made by calculating a material balance and a heat balance for various charges with 50 to 70 per cent of wash metal in the charge mix for comparison with the present average melting practice of 50 per cent ordinary hot metal and 50 per cent scrap in stationary furnaces. A discussion of the procedure used in these calculations is presented in the Appendix.

The material balances of the various open hearth heats are shown in the appendix; the oxygen balance, weight of iron ore, limestone and slag per ton of steel are exhibited for each heat. Figure 2 also exhibits these data. On hot metal heats a flush slag becomes necessary because of the high slag volume when over 50 per cent hot metal is charged. The greatly decreased iron ore and limestone required for the wash metal heats is evident and the highest wash metal charge (70 per cent) has a slag weight of only 130 lb of slag per ton of molten steel.

A summary of heat balances for the different open hearth charges is given in Table I. These calculations are based on the methods of Darken[3] in Chapter 19 of the 1951 Edition of "Basic Open Hearth Steelmaking." See Tables VI through XVI. The results obtained on the conventional 50 per cent hot metal heat agree with several previous papers and the heat balances of the wash metal heats were calculated on the same basis.

Figure 3 shows the required thermal and electrical energy for the various charges. The heat balances for open hearth furnaces show the large decrease in fuel required to melt wash metal heats as compared to normal hot metal heats. This is due to three factors: (1) smaller ore and limestone charge, (2) higher wash

TABLE I

Summary of Material Balances and Heat Balances

Open Hearth Heats

I. Material balance (lb per ton liquid steel in furnace)	40 Per cent hot metal	50 Per cent hot metal	50 Per cent wash metal	60 Per cent wash metal	70 Per cent wash metal
Hot (wash) metal	809.41	1001.90	1000.08	1188.44	1373.11
Scrap	1214.11	1001.90	1000.08	792.29	588.48
Limestone	125.6	166.1	61.4	81.3	104.4
Ore	81.7	149.7	70.2	120.6	174.3
Slag	152.5	202.4	75.2	100.2	129.1
Per cent FeO in slag	14.49	16.23	11.51	13.14	15.97
II. Heat balance (million Btu per ton)					
A. Output					
1. Heat in steel	1.1900	1.1900	1.1900	1.1900	1.1900
2. Heat in slag	0.1292	0.1660	0.0617	0.0822	0.1059
3. Heat in evolved gases	0.0953	0.1217	0.0737	0.0920	0.1106
4. Heat to decompose ore	0.1082	0.2116	0.1097	0.1912	0.2738
5. Heat to decompose limestone	0.0956	0.1264	0.0467	0.0619	0.0794
6. Heat to decompose H_2O	0.0071	0.0115	0.0060	0.0092	0.0127
Total	1.6254	1.8272	1.4878	1.6265	1.7724
B. Input					
7. Heat in hot (wash) metal	0.4225	0.5230	0.6130	0.7285	0.8417
8. Heat in oxygen (air)	0.0192	0.0159	0.0158	0.0125	0.0093
9. Heat of oxidation C	0.0446	0.0461	0.0862	0.0950	0.1007
10. Heat of oxidation Si	0.1016	0.1254	0.0198	0.0235	0.0269
11. Heat of oxidation Mn	0.0273	0.0318	0.0122	0.0120	0.0117
12. Heat of oxidation P	0.0186	0.0230	0.0251	0.0298	0.0344
13. Heat of formation Ca_2SiO_4	0.0195	0.0263	0.0067	0.0097	0.0128
14. Heat of formation $Ca_3P_2O_8$	0.0073	0.0091	0.0100	0.0116	0.0135
15. Heat of combustion $CO + H_2$ (20 per cent efficient)	0.0794	0.1005	0.0629	0.0765	0.0906
Total	0.7400	0.9011	0.8517	0.9991	1.1416
C. Metallurgical heat required	0.8854	0.9261	0.6361	0.6274	0.6308
Fuel Btu @ 25 per cent efficiency 1000 Btu per ton	3.5416	3.7044	2.5444	2.5096	2.5232

metal temperature, and (3) much lower slag volume. The difference between the total heat necessary to melt a ton of low carbon steel and the heat generated in chemical reactions plus the surplus heat in hot metal or wash metal is termed the metallurgical heat requirement (MHR) and this must be supplied by fuel in the open hearth. The thermal efficiency of fuel combustion was assumed at 25 per cent.

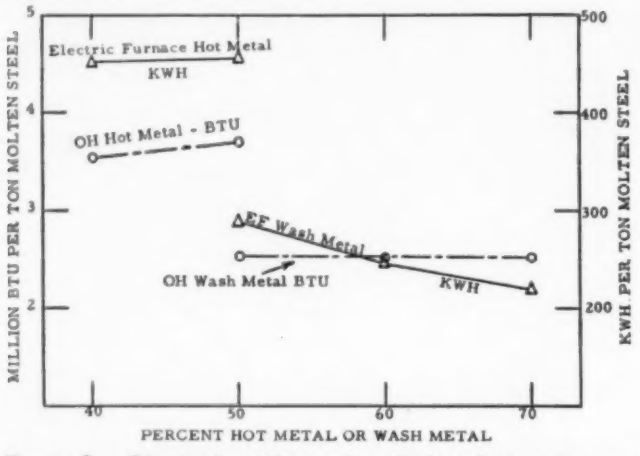


Figure 3 — Chart gives thermal and electrical energy required for various charges.

Woods and Taylor[4] have reported studies of production rates on 180 ton furnaces with varying amounts of hot metal; Greene[5] has reported similar data on 230-ton furnaces. These papers give the results of a statistical study of melting rates covering several thousand heats in two different plants and their information agrees favorably with King's average melting rates. The melting rates given by Woods and Taylor and Greene are plotted on Figure 4. This also shows the influence of furnace size on production rate.

The heat balances for the hot metal heats show little variation in total heat requirements or in metallurgical heat requirement. This is due mostly to the fact that more ore must be charged with increasing hot metal and the extra heat required to decompose the extra ore balances the increased sensible heat supplied with higher percentages of hot metal. The same result was obtained in the wash metal heats charged with the 3 per cent carbon, 0.2 per cent silicon wash metal. However the total heat required in the wash metal was only about 65 per cent of that required in the normal hot metal heats. As a consequence of the much higher temperature of the desiliconized wash metal and the reduced heat requirement, it is obvious that the working and refining period following the completion of charging would be much shorter than that with normal hot metal heats. The charge would be nearly at the tapping temperature and reactions would be much more rapid; in addition the amount of metalloid impurities added with the hot metal would be only half that of a normal hot metal heat. It is therefore estimated that the working period would be reduced in proportion to the reduction in the total heat requirement. These time periods for the different stages of making open hearth heats with various amounts of hot metal and wash metal are shown in Table II and are also plotted on Figure 4 in order to show the comparison between the expected production with wash metal heats and normal hot metal heats. The increase is about 25 per cent.

TABLE II

Estimated Production Rates for 225-Ton Open Hearth Heats

	Charge, per cent			
	50 Hot metal*	50 Wash metal	60 Wash metal	70 Wash metal
Begin charge to finish scrap, hr:min	1:45	1:45	1:25	1:05
Finish scrap to finish hot metal, hr:min	2:00	1:30	1:15	1:00
Hot metal to melt, hr:min	4:15	2:50	2:25	2:00
Melt to tap, hr:min	2:30	1:40	1:40	1:40
Delays, hr:min	1:15	1:15	1:15	1:15
Tap-to-tap, hr:min	11:45	9:00	8:00	7:00
Net tons per operating hour	19.15	25.00	28.13	32.13

*From King (2) Table IV.

King(2) gives a much more optimistic estimate of the effect of charging fully desiliconized and decarburized blown metal and exhibits a table for heats charged with 55, 65, and 80 per cent blown metal with tap-to-tap times of 6:15, 4:45, 4:45 hour:min, and melting rates of 36.0, 39.1, 47.4 tons per hour compared to nine hours melting time and 25 tons per hour for the best possible future melting practice on 225-ton furnaces using normal hot metal.

The estimate of melting rates for the various hot metal and wash metal charges was also calculated by relating the total sensible heat in the hot metal to the period from beginning charge to finish hot metal and the metallurgical heat requirement for each heat to the operating period from finish hot metal to tap. These calculations agreed very closely with Greene's hot metal heat data and King's estimates for both hot metal and blown metal heats; in fact the melting rates calculated in this manner for wash metal heats was somewhat higher than shown in Table II.

This increase in melting rate of 25 per cent for a 50 per cent wash metal charge, if applied to the 94,000,000

Figure 4 — Melting rates for various size furnaces with varying percentages of molten metal are given by the chart.

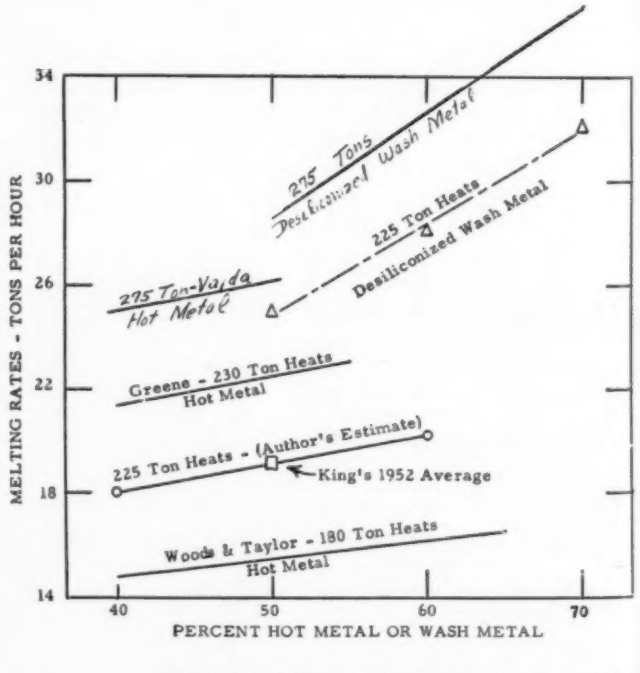

275 Tons Desiliconized Wash Metal
225 Ton Heats Desiliconized Wash Metal
275 Ton-Valda Hot Metal
Greene - 230 Ton Heats Hot Metal
225 Ton Heats - (Author's Estimate)
King's 1952 Average
Woods & Taylor - 180 Ton Heats Hot Metal
MELTING RATES - TONS PER HOUR
PERCENT HOT METAL OR WASH METAL

TABLE III

Estimated Open Hearth Cost Per Ton Steel — 225-Ton Furnace

	50 Per cent Hot metal	50 Per cent Wash metal	60 Per cent Wash metal	70 Per cent Wash metal
Fuel @ $0.65 per 1000 Btu	2.40	1.65	1.63	1.64
Direct labor	3.35	2.52	2.24	1.99
Maintenance and repair—labor	0.60	0.45	0.40	0.35
Fluxes	0.33	0.30	0.28	0.25
Refractories and rebuild	2.50	2.40	2.40	2.25
Molds	0.65	0.65	0.65	0.65
Supplies	0.25	0.25	0.25	0.25
Water, steam, etc.	0.30	0.30	0.30	0.30
Switching	0.20	0.20	0.20	0.20
Slag disposal	0.30	0.28	0.20	0.20
Overhead	1.00	0.75	0.67	0.58
Capital charges	4.00	3.00	2.67	2.35
Total cost above	15.88	12.85	11.89	11.01
Hot metal @ $33.00 per ton	17.60			
Wash metal @ $36.00 per ton		19.24	22.83	26.37
Scrap @ $36.00 per ton*	19.20	19.24	15.22	11.30
Limestone @ $4.00 per ton	0.35	0.13	0.17	0.22
Ore @ $14.00 per ton*	1.12	0.53	0.61	0.78
Deoxidizers	1.50	1.50	1.50	1.50
Cost material	39.77	40.64	40.33	40.17
Total cost	55.65	53.49	52.22	51.18

*Iron Age, June 30, 1955

tons of stationary open hearth capacity, would enable an increased production of over 20,000,000 tons of steel from installed stationary furnaces, and save much of the new capital investments estimated by Mr. Homer in his recent address before the American Iron and Steel Institute. The cost of producing steel by the use of wash metal would also be somewhat cheaper as shown in Table III. The costs given in this table were estimated partly from the discussion of comparative costs in open hearth and electric furnaces in the Battelle Institute[6] report "Comparative Economics of Open Hearth and Electric Furnaces for Production of Low Carbon Steel" in 1952. Table III includes changes in scrap, labor, etc, representing the situation in 1955. It will be evident that all of the wash metal heats are cheaper to produce even when the extra cost of wash metal over hot metal is included. The wash metal heats, because of the faster melting rate, have a lower capital, overhead and supervision, labor, fuel, iron ore and limestone cost. These factors reduce the total cost up to about $4.00 per ton of ingots. The oxygen cost for desiliconizing hot metal is included in the conversion cost of $36 per ton for wash metal made from $33 hot metal. This reduction in stationary open hearth costs would make these older furnaces quite competitive with the lower production costs now being claimed for new steelmaking processes such as the oxygen-blown converter.

ELECTRIC FURNACE OPERATION

At the end of World War II the production capacity of electric furnace steel was approximately 5,000,000 tons. The present electric furnace capacity is given by the 1954 Edition of the Iron and Steel Directory as 10,807,110 tons or 8.6 per cent of total steel capacity. Of this total capacity, approximately 2,203,000 tons are located at integrated plants with 28 furnaces of over 65 ton capacity. The modern large electric furnaces which are located at integrated plants with hot metal available could use large amounts of desiliconized hot metal to increase output with decreased power and operating costs. The discussion herein relates entirely to such situations. Figure 5 shows the frequency distribution of electric arc furnaces by capacities.

Although ordinary hot metal has been used in electric furnaces at various times, this practice has never been adopted and no publications are available which describe such procedure. The use of ordinary hot metal (4 per cent C, 1 per cent Si) in large amounts (over 30 per cent) in electric furnaces would involve the charging of large amounts of ore and limestone with the cold scrap and melting down with the arc before the hot metal is added. In the small volume of the electric furnace, the large quantities of CO gas evolved from the ore and limestone reactions with carbon in the hot metal might develop violent uncontrollable boils. Calculations indicate that a 50 per cent charge of ordinary hot metal would generate about 100,000 cu ft of CO gas from a 100-ton melt or about 20,000 cfhr for a five-hour heat. In addition, there is limited oxidation of scrap when it is melted in the reducing atmosphere of the electric furnace, so more iron ore would be necessary to supply oxygen than in the open hearth, for a given percentage of hot metal in the charge mix. The large slag volume from a 50 per cent hot metal charge (220 lb per ton of steel) would also make several flushes necessary with such a charge. It seems obvious that the addition of ordinary hot metal to large electric furnaces in amounts over 25 per cent of the charge will usually be impractical and past experience verifies this conclusion.

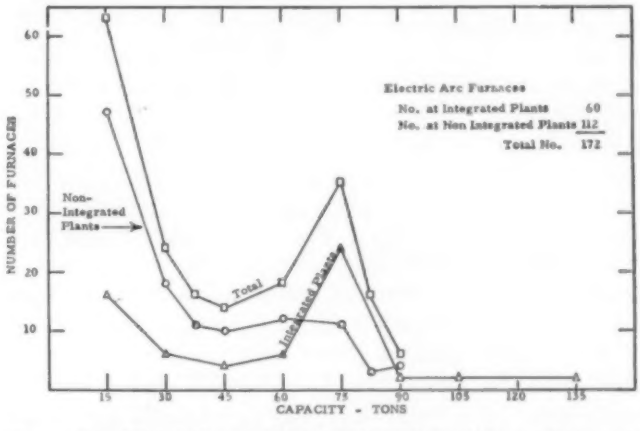


Figure 5 — Chart shows distribution of electric arc furnaces by size in the United States.

In the past the steel industry has favored two sizes of electric furnaces. Of the total number of 175 furnaces installed, 64 furnaces have a capacity of 10 to 20 tons and 70 furnaces have capacities between 60 to 80 tons. Most recent installations have ranged between 75 to 150 tons. If it be assumed that these large electric furnaces are competitive with large stationary open hearth furnaces for the production of ordinary low carbon steel, a study of the value of charging desiliconized hot metal becomes more logical.

A series of calculations using 50 to 70 per cent of desiliconized hot metal in the electric furnace were made in a similar manner as those for the stationary open

TABLE IV

Summary of Material Balances and Heat Balances

Electric Furnace Heats

I. Material balance (pounds per ton liquid steel in furnace)	Cold metal charge	40 Per cent hot metal	50 Per cent hot metal	50 Per cent wash metal	60 Per cent wash metal	70 Per cent wash metal
Hot (wash) metal	161.36(1)	793.95	986.10	984.52	1175.09	1363.58
Scrap	1866.26	1190.93	986.10	984.52	783.39	584.39
Sand	9.00	.....	.....	8.16	6.68	6.05
Limestone (lime)	35.4(2)	141.1	178.2	52.7(2)	55.8(2)	64.5(2)
Ore	.....	155.3	209.5	120.1	148.3	181.3
Slag	77.0	172.8	218.5	117.7	124.7	144.2
Per cent FeO in slag	18.18	16.04	16.84	16.00(3)	16.00(3)	16.00(3)
II. Heat balance (1000 Btu per ton)						
A. Output						
1. Heat in steel	1.1900	1.1900	1.1900	1.1900	1.1900	1.1900
2. Heat in slag	0.0634	0.1417	0.1792	0.0965	0.1023	0.1182
3. Heat in evolved gases	0.0155	0.1037	0.1295	0.0442	0.0524	0.0610
4. Heat to decompose ore	.....	0.2291	0.3095	0.1821	0.2290	0.2821
5. Heat to decompose limestone	.....	0.1074	0.1356	.....	.....	.....
6. Heat to decompose H_2O	0.0214	0.0120	0.0155	0.0094	0.0111	0.0131
Total	1.2903	1.7839	1.9593	1.5222	1.5848	1.6644
B. Input						
7. Heat in hot (wash) metal	.....	0.4144	0.5147	0.6232	0.7438	0.8631
8. Heat in oxygen (air)	0.0122	0.0068	0.0056	0.0056	0.0045	0.0033
9. Heat of oxidation C	0.0307	0.0280	0.0323	0.0877	0.1046	0.1213
10. Heat of oxidation Si	0.0203	0.0995	0.1233	0.0193	0.0230	0.0266
11. Heat of oxidation Mn	0.0155	0.0265	0.0299	0.0118	0.0117	0.0116
12. Heat of oxidation P	0.0038	0.0182	0.0226	0.0247	0.0336	0.0341
13. Heat of formation Ca_2SiO_4	0.0110	0.0226	0.0287	0.0155	0.0160	0.0175
14. Heat of formation $Ca_3P_2O_8$	0.0070	0.0073	0.0091	0.0097	0.0131	0.0134
15. Heat of combustion $CO + H_2$ (20 per cent efficiency)	0.0156	0.0818	0.1022	0.0342	0.0407	0.0472
Total	0.1170	0.7051	0.8684	0.8317	0.9910	1.1381
C. Metallurgical heat required	1.1733	1.0788	1.0909	0.6905	0.5938	0.5263
Kwhr per ton at 70 per cent efficiency	491	451	456	289	248	220

(1) 8 per cent cold pig

(2) Lime

(3) 16 per cent FeO assumed and sand added to provide sufficient slag volume.

hearth heats. When a 3 per cent carbon with 0.20 per cent silicon is used for wash metal, the volume of evolved gas steadily increases as the percentage of wash metal in the charge increases to amounts approaching 50,000 cfhr with 70 per cent wash metal. In order to overcome this problem, a wash metal containing 2 per cent carbon and 0.10 per cent silicon at a temperature of 3000 F was postulated for electric furnace operations. Material balances and heat balances were then calculated with this modified wash metal using the same principles as in the open hearth furnaces. The oxygen required for such charge mixes is less than half that required for ordinary hot metal (4 per cent C and 1 per cent Si) and the iron ore necessary is reduced accordingly. In addition, the amount of silica in the charge is so low that no limestone is needed and a synthetic slag made by proper additions of sand and lime would be desirable to produce a satisfactory slag volume. The use of burnt lime instead of limestone also reduces the gas evolved.

A theoretical study of melting conditions was made by making material balance calculations for the following types of charges:

1. Cold melt practice — 92 per cent scrap.
2. 40 and 50 per cent normal hot metal containing 4 per cent C and 1 per cent Si.
3. 50, 60, and 70 per cent wash metal (2 per cent C, 0.10 per cent Si).

Table IV shows the composite data for materials charged, heat balance, and energy requirements to melt these various charges. The same data are presented in Figures 3 and 6. The great decrease in ore and lime additions, slag weight, and gases evolved for the wash metal heats as compared to the hot metal heats is quite obvious in Figure 6. It is believed that the use of this type of wash metal in electric furnaces could be handled without difficulty and the output of the furnaces would be about double the output obtained with the standard cold scrap charge.

The reduction in the MHR factor and the calculated kwhr requirement as shown in Table IV and in Figure 3 is quite large and indicates that a large reduction in power costs in electric furnace operations is possible. This is the highest cost item in electric furnace melting. A comparable decrease in electrode consumption is also indicated. This effect is largely due to the high heat content of the superheated wash metal at 3000 F.

In a paper presented at the December 1953 Electric Furnace Steel Conference, Ramseyer[7] calculates the theoretical power requirement for a cold scrap charge in a 20-ft diam arc furnace (100-ton capacity) as 355 kwhr per ton of steel. Since a charge containing 60 per

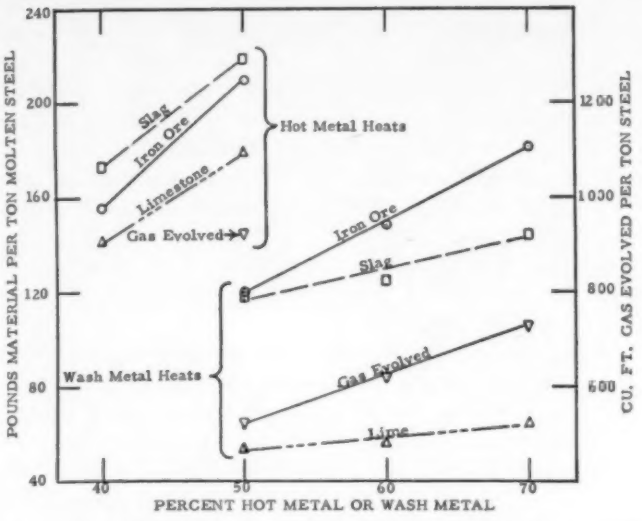


Figure 6 — Charge components for electric furnace heats are given by the chart.

cent wash metal at 3000 F has about half of the heat required in the metal charged, the theoretical power requirement should be about half of 355 kwhr. This checks very closely with the theoretical MHR for the 60 per cent wash metal heat indicated in Table IV if the MHR is converted to kwhr (593,800 Btu = 174 kwhr). The usual power consumption is 500 kwhr per ton of steel for large furnaces charged with 100 per cent cold scrap. There are thus about 140 kwhr (500 minus 355 kwhr) used to balance radiation losses, holding times during refining periods, cooling water loss, etc. These losses should be much less for a wash metal heat requiring 2.5 hours time than for a cold scrap heat taking 4 to 4.5 hours. Thus, assuming losses of 100 kwhr, such a 60 per cent wash metal heat might consume 174+100=274 kwhr per ton of steel — about 55 per cent of the power required for a cold scrap heat.

Several plants operating 75 to 90 ton furnaces are melting cold scrap heats in 4.5 hours with power consumption of 500 kwhr per ton of steel. Table V shows the estimated time for a cold scrap heat and a 60 per cent wash metal heat using Ramseyer's figures as a basis of reference. In this table, Ramseyer's time figures certainly represent the most favorable conditions for cold scrap melting, as the normal melting rate for cold scrap melts in large electric furnaces is between 16 and 20 tons per hour. It will be noted that the wash metal is charged in two stages at 15-minute intervals to allow time for the ore-carbon reaction to take place without too much gas evolution at one time. The slag volumes in the three wash metal heats are under 150 lb per ton and this should eliminate slag flushes.

TABLE V

Time of Heat (Tap-to-Tap) Electric Furnace

100-Ton furnace estimated times	RAMSEYER[5]— Cold Scrap— Heat time— min	60 Per cent wash metal, 40 per cent scrap heat time— min
1. Top charging cold scrap and ore	25	15
2. Scrap meltdown time	145	50
3. Second half wash metal		15
4. Refining period	25	25
5. Fettling time	25	20
6. Delay time	25	25
Total time	245	150
Melting rate tons per hr	24	40

Since no large-scale use of hot metal in electric furnaces has been reported, and because of the almost complete lack of reliable information on this subject, any comparative cost estimates for the use of wash metal in electric furnaces are quite speculative. However, the chemical and physical operations of making carbon steel in both types of furnaces are so analagous that the result of charging large amounts of wash metal to electric furnaces should have a similar effect in increasing production and lowering melting costs. On the basis of rough cost estimates made in a similar manner to the open hearth costs given in Table III, the cost of 60 per cent wash metal electric furnace steel would be approximately the same as that of the 60 per cent wash metal open hearth steel.

The introduction of the desiliconizing operation into steel plants will require some new equipment. Interest in the method has become quite lively in Europe and experimental work in mixers, iron ladles and converters has been done. In India, the Tata Iron and Steel Company has even assigned one open hearth for this operation. This Tata method is certainly clumsy as the desiliconizing furnace has to be charged through the doors and tapped through the bottom tap hole for each batch of wash metal made. The desiliconizing must be done in some unit weight of batch, treated with an exact amount of oxygen for some determined precise period, if uniform and consistent results as to wash metal temperature and composition are to be achieved. This operation can probably best be controlled by doing it in some form of converter. No consistent results have been obtained by blowing oxygen into iron ladles or mixers. Also the high temperatures reached would require other ladle and mixer lining refractories than the fire clay bricks most generally used in such equipment at this time.

SUMMARY

An open hearth plant now producing 1,000,000 tons of steel per year could produce 1,400,000 tons with the use of a charge containing 60 per cent desiliconized wash metal. Based on 350 operating days per year, production would amount to 4,000 tons of steel per day. This would require 2,933 tons of ordinary hot metal to yield 2,640 tons of wash metal. The desiliconizing operation could be accomplished in one 30-ton converter which would produce 150 tons of wash metal per hour or 3,600 tons per day. If high pressure oxygen is used, no blowing equipment would be required and the converter installation would consist of the basic-lined converter plus the necessary cranes, jack cars, slag cars, hot metal ladles, refractory house, drying oven and dust control, together with the necessary oxygen supply of about 100 tons per day. It is estimated that such an installation would cost about $3,000,000. This represents an investment cost for the extra output of about $3.33 per annual ingot tons compared to the present $30 to $40 per ton for new open hearth installations. Comparable results seem possible in electric furnace plants where hot metal is available.

Although most of the data in this paper are theoretical, actual practice regarding material and heat balances check the calculations included in the tables. The possibilities of using desiliconized hot metal certainly indicate that a large increase in production in both open hearth and electric furnaces could be obtained with some decrease in cost. It is believed that the estimates of production rates are conservative and that the use of desiliconized hot metal as a means to increase steel production merits a thorough trial on a large scale before more new steel plants are constructed. Because of the probability of successful utilization of wash metal in the electric furnace, it would also seem desirable to give proper consideration to the differences in capital costs between electric and open hearth furnaces when additional capacity is required.

APPENDIX I

Eleven theoretical conditions for making heats of 0.20 per cent carbon steel were considered; 40 and 50 per cent hot metal; 50, 60, and 70 per cent desiliconized hot metal in both the open-hearth and electric furnace processes, and a cold metal electric furnace charge. These calculations are based on the methods of Darkin[3] in Chapter 19 of the 1951 Edition of "Basic Open Hearth Steelmaking". The following assumptions were made in calculating the material balances:

1. Approximately two-thirds of the carbon dioxide from the limestone reacts with carbon to form carbon monoxide. This corresponds to 10.3 per cent of the limestone being considered as oxygen.
2. Ten per cent of the remaining carbon is oxidized to carbon dioxide and ninety per cent to carbon monoxide.
3. Fifty pounds of oxygen are taken up from the atmosphere for each ton of scrap melted in the open-hearth process; eighteen in the electric furnace.
4. Twenty-four per cent of the weight of the ore is available oxygen.
5. The ratio, $CaO/SiO_2 + P_2O_5$, in the slag was assumed to be 2.5.
6. The CaO in the slag was assumed to be 45 per cent, MgO 6 per cent, Al_2O_3, etc, 8 per cent.
7. Hot metal analysis is 4 per cent carbon, 1 per cent manganese, 1 per cent silicon, 0.25 per cent phosphorous.
8. Wash metal analysis is 3 per cent carbon, 0.40 per cent manganese, 0.20 per cent silicon, 0.27 per cent phosphorous for the open-hearth heats; and 2 per cent carbon, 0.40 per cent manganese, 0.10 per cent silicon, 0.27 per cent phosphorous in the electric furnace heats.
9. Tapped steel analysis is 0.20 per cent carbon, 0.20 per cent manganese, 0.05 per cent silicon, 0.03 per cent phosphorous.

Using these assumptions, a set of seven equations in seven unknowns was established. The unknowns were: per cent FeO in slag, pounds of hot or wash metal, scrap, limestone and ore charged, pounds of slag produced, and pounds of iron reduced from slag to metal. The equations represented oxygen, silica, lime, iron, and slag balances. These equations were then reduced to a set of four linear equations which were solved by standard matrix inversion techniques, using IBM punch card machines.

In the case of desiliconized hot metal in the electric furnace, sand was added to the charge to insure an adequate slag volume, and burnt lime was substituted for limestone.

Subsequent to the calculation of the material balances, control panels were wired which enabled the metallurgical heat requirements to be computed easily on IBM equipment.

Material balance calculations are given in Tables VI through XVI. The summary of material balances and heat balances are given in Tables I and IV.

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TABLE VI

40 Per Cent Hot Metal, Open Hearth Material Balance

Material		Carbon		Manganese		Phosphorous		Silicon		Iron	
	Total, lb	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent
Hot metal	809.41	32.38	4.00	8.09	1.00	2.02	0.25	8.09	1.00	758.4	93.70
Scrap	1214.11	2.43	0.20	4.86	0.40	0.36	0.03	0.01	0.05	1205.6	99.30
Total	2023.52	34.81	...	12.95	...	2.38	...	8.70	...	1964.0	...
Final steel	2000.00	4.00	0.20	4.00	0.20	0.60	0.03	1.00	0.05	1990.0	99.50
Amount Oxidized	.....	30.81	...	8.95	...	1.78	...	7.70	...	—26	...
Oxygen required	61.60	43.89	...	1.71	...	2.30	...	8.78	...	4.92	...

Material	Total, lb	CaO		MnO		P_2O_5		SiO_2		FeO		MgO		Oxygen	
		Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent
Limestone	125.6	67.82	54.00	...	...	...	...	2.51	2.00	...	...	...	...	12.94	10.30
Ore	81.7	0.82	1.00	0.82	1.00	0.12	0.15	4.08	5.00	...	...	...	...	19.61	24.00
Charge	...	...	...	10.66	...	4.08	...	16.48	...	...	...	9.15	...	30.35	(2.50 per cent in scrap)
Slag	152.5	68.64	45.01	11.48	7.53	4.20	2.75	23.07	15.13	22.10	14.49	9.15	6.00	...	....
Total oxygen supplied	...	...	...	...	...	...	...	...	...	...	...	...	...	62.90	....

TABLE VII

50 Per Cent Hot Metal, Open Hearth Material Balance

Material	Total, lb	Carbon		Manganese		Phosphorous		Silicon		Iron	
		Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent
Hot metal	1001.90	40.08	4.00	10.02	1.00	2.50	0.25	10.01	1.00	938.78	93.70
Scrap	1001.90	2.00	0.20	4.01	0.40	0.30	0.03	0.50	0.05	994.89	99.30
Total	2003.80	42.08	...	14.03	...	2.80	...	10.51	...	1933.67	...
Final steel	2000	4.00	0.20	4.00	0.20	0.60	0.03	1.00	0.05	1990	99.50
Amount oxidized	...	38.08	...	10.43	...	2.20	...	9.51	...	—56	...
Oxygen required	78.18	54.14	...	3.04	...	2.84	...	10.85	...	7.32	...

Material	Total, lb	CaO		MnO		P_2O_5		SiO_2		FeO		MgO		Oxygen	
		Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent
Limestone	166.1	89.69	54.00	...	...	...	...	3.32	2.00	...	...	...	...	17.11	10.30
Ore	149.7	1.50	1.00	1.50	1.00	0.22	0.15	7.48	5.00	...	...	...	...	35.93	24.00
Charge	...	...	...	13.47	...	5.04	...	20.36	...	...	...	12.14	...	25.05	(2.50 per cent in scrap)
Slag	202.4	91.19	45.06	14.97	7.40	5.26	2.60	31.16	15.40	32.85	16.23	12.14	6.00	...	...
Total oxygen supplied	...	...	...	...	...	...	...	...	...	...	...	...	...	78.09	...

TABLE VIII

50 Per Cent Wash Metal, Open Hearth Material Balance

Material	Total, lb	Carbon		Manganese		Phosphorous		Silicon		Iron	
		Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent
Wash metal	1000.08	30.00	3.00	4.00	0.40	2.70	0.27	2.00	0.20	964.08	96.40
Scrap	1000.08	2.00	0.20	4.00	0.40	0.30	0.03	0.50	0.05	993.08	99.30
Total	2000.16	32.00	...	8.00	...	3.00	...	2.50	...	1957.16	...
Final steel	2000	4.00	0.20	4.00	0.20	0.60	0.03	1.00	0.05	1990	99.50
Amount oxidized	...	28.00	...	4.00	...	2.40	...	1.50	...	—33	...
Oxygen required	48.33	40.43	...	1.16	...	3.10	...	1.71	...	1.93	...

Material	Total, lb	CaO		MnO		P_2O_5		SiO_2		FeO		MgO		Oxygen	
		Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent
Limestone	61.4	33.16	54.00	...	...	...	...	1.23	2.00	...	...	...	...	6.32	10.30
Ore	70.2	0.70	1.00	0.70	1.00	0.11	0.15	3.51	5.00	...	...	...	...	16.85	24.00
Charge	...	...	...	5.16	...	5.50	...	3.21	...	...	...	4.51	...	25.00	(2.50 per cent in scrap)
Slag	75.2	33.86	45.03	5.86	7.79	5.61	7.46	7.95	10.57	8.66	11.51	4.51	6.00	...	...
Total oxygen supplied	...	...	...	...	...	...	...	...	...	...	...	...	...	48.17	...

TABLE IX

60 Per Cent Wash Metal, Open Hearth Material Balance

Material	Total, lb	Carbon		Manganese		Phosphorous		Silicon		Iron	
		Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent
Wash metal	1188.44	35.65	3.00	4.75	0.40	3.21	0.27	2.38	0.20	1145.66	96.40
Scrap	792.29	1.58	0.20	3.17	0.40	0.24	0.03	0.40	0.05	786.74	99.3
Total	2160.73	37.23	...	7.92	...	3.45	...	2.78	...	1932.40	...
Final steel	2000	4.00	0.20	4.00	0.20	0.60	0.03	1.00	0.05	1990	99.50
Amount oxidized	...	33.23	...	3.92	...	2.85	...	1.78	...	—58	...
Oxygen required	57.68	47.90	...	1.14	...	3.68	...	2.03	...	2.93	...

Material	Total, lb	CaO		MnO		P_2O_5		SiO_2		FeO		MgO		Oxygen	
		Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent
Limestone	81.3	43.90	54.00	...	...	...	...	1.63	2.00	...	...	...	...	8.37	10.30
Ore	120.6	1.21	1.00	1.21	1.00	0.18	0.15	6.03	5.00	...	...	...	...	28.94	24.00
Charge	...	...	...	5.06	...	6.53	...	3.81	...	...	...	6.01	...	19.81	(2.50 per cent in scrap)
Slag	100.2	45.11	45.01	6.27	6.26	6.71	6.70	11.47	11.45	13.17	13.14	6.01	6.00	...	...
Total oxygen supplied	...	...	...	...	...	...	...	...	...	...	...	...	...	57.12	...

TABLE X

70 Per Cent Wash Metal, Open Hearth Material Balance

Material	Total, lb	Carbon		Manganese		Phosphorous		Silicon		Iron	
		Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent
Wash metal	1373.11	41.20	3.00	5.49	0.40	3.71	0.27	2.75	0.20	1323.68	96.40
Scrap	588.48	1.18	0.20	2.35	0.40	0.18	0.03	0.29	0.05	584.36	99.30
Total	.....	42.38	...	7.84	...	3.89	...	3.04	...	1908.04	...
Final steel	2000	4.00	0.20	4.00	0.20	0.60	0.03	1.00	0.05	1990	99.50
Amount oxidized	.....	38.38	...	3.84	...	3.29	...	2.04	...	—82	...
Oxygen required	68.26	55.22	...	1.87	...	4.25	...	2.33	...	4.59	...

Material	Total, lb	CaO		MnO		P_2O_5		SiO_2		FeO		MgO		Oxygen	
		Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent
Limestone	104.4	56.38	54.00	...	...	...	...	2.09	2.00	...	...	...	...	10.75	10.30
Ore	174.3	1.74	1.00	1.74	1.00	0.26	0.15	8.72	5.00	...	...	...	...	41.83	24.00
Charge	...	...	...	5.71	...	7.54	...	4.37	...	...	...	7.75	...	14.71	(2.50 per cent in scrap)
Slag	129.1	58.12	45.02	7.45	5.77	7.80	7.04	15.18	11.76	20.62	15.97	7.75	6.00	...	...
Total oxygen supplied	...	...	...	...	...	...	...	...	...	...	...	...	...	67.29	...

TABLE XI

Electric Furnace Cold Metal Charge — (8 Per Cent Cold Pig)

Material	Total, lb	Carbon		Manganese		Phosphorous		Silicon		Iron	
		Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent
Cold pig iron	161.36	6.45	4.00	1.61	1.00	0.40	0.25	1.61	1.00	150.87	93.50
Scrap	1866.22	3.73	0.20	7.46	0.40	0.56	0.03	0.93	0.05	1853.20	99.30
Total	2027.58	10.18	...	9.08	...	0.96	...	2.54	...	2004.07	...
Final steel	2000	4.00	0.20	4.00	0.20	0.60	0.03	1.00	0.05	1990	99.50
Amount oxidized	.....	6.18	...	5.08	...	0.36	...	1.54	...	—14	...
Oxygen required	16.77	9.06	...	1.48	...	0.46	...	1.76	...	4.01	...

Material	Total, lb	CaO		MnO		P_2O_5		SiO_2		FeO		MgO		Oxygen	
		Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent
Lime	34.5	34.69	98.00	...	...	...	...	0.71	2.00	...	...	...	...	...	...
Sand	9.0	...	...	...	...	...	...	9.00	100.00	...	...	...	...	...	...
Charge	...	...	...	6.56	...	0.82	...	3.30	...	...	...	4.62	...	16.80	(0.90 per cent in scrap)
Slag	77.0	34.69	45.05	6.56	8.51	0.82	1.06	13.01	16.90	18.01	18.18	4.62	6.00	...	...
Total oxygen supplied	...	...	...	...	...	...	...	...	...	...	...	...	...	16.80	...

TABLE XII

40 Per Cent Hot Metal, Electric Furnace Material Balance

Material	Total, lb	Carbon		Manganese		Phosphorous		Silicon		Iron	
		Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent
Hot metal	793.95	31.76	4.00	7.94	1.00	1.98	0.25	7.94	1.00	743.93	93.70
Scrap	1190.93	2.38	0.20	4.76	0.40	0.36	0.03	0.60	0.05	1182.59	99.30
Total	1984.88	34.14	...	12.70	...	2.34	...	8.54	...	1926.52	...
Final Steel	2000	4.00	0.20	4.00	0.20	0.60	0.03	1.00	0.05	1990	99.50
Amount oxidized	.....	30.14	...	8.70	...	1.74	...	7.54	...	—63	...
Oxygen required	63.72	44.21	...	2.53	...	2.25	...	8.60	...	6.13	...

Material	Total, lb	CaO		MnO		P_2O_5		SiO_2		FeO		MgO		Oxygen	
		Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent
Limestone	141.1	76.19	54.00	...	...	...	...	2.82	2.00	...	...	...	...	14.53	10.30
Ore	155.3	1.55	1.00	1.55	1.00	0.23	0.15	7.76	5.00	...	...	...	...	37.27	24.00
Charge	...	...	...	11.23	...	3.99	...	16.14	...	...	...	10.37	...	10.72	(0.90 per cent in scrap)
Slag	172.8	77.74	44.99	12.78	7.40	4.22	2.44	26.72	15.46	27.53	15.93	10.37	6.00	...	...
Total oxygen supplied	...	...	...	...	...	...	...	...	...	...	...	...	...	62.52	...

TABLE XIII

50 Per Cent Hot Metal, Electric Furnace Material Balance

Material	Total, lb	Carbon		Manganese		Phosphorous		Silicon		Iron	
		Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent
Hot metal	986.10	39.44	4.00	9.86	1.00	2.46	0.25	9.86	1.00	923.76	93.70
Scrap	986.10	1.97	0.20	3.94	0.40	0.30	0.03	0.49	0.05	979.19	99.30
Total	1972.2	41.41	...	13.80	...	2.76	...	10.35	...	1902.95	...
Final steel	2000	4.00	0.02	4.00	0.02	0.60	0.03	1.00	0.05	1990	99.50
Amount oxidized	.....	37.41	...	9.80	...	2.16	...	9.35	...	—87	...
Oxygen required	77.53	53.03	...	2.85	...	2.79	...	10.66	...	8.20	...

Material	Total, lb	CaO		MnO		P_2O_5		SiO_2		FeO		MgO		Oxygen	
		Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent
Limestone	178.2	96.23	54.00	...	...	...	...	3.56	2.00	...	...	...	...	18.35	10.30
Ore	209.5	2.10	1.00	2.10	1.00	0.31	0.15	10.48	5.00	...	...	...	...	50.28	24.00
Charge	...	...	...	12.65	...	4.95	...	20.01	...	...	...	13.11	...	8.87	(0.90 per cent in scrap)
Slag	218.5	98.33	45.00	14.75	6.75	5.26	2.41	34.05	15.58	36.80	16.84	13.11	6.00	...	...
Total oxygen supplied	...	...	...	...	...	...	...	...	...	...	...	...	...	77.50	...

TABLE XIV

50 Per Cent Wash Metal, Electric Furnace Material Balance

Material	Total, lb	Carbon		Manganese		Phosphorous		Silicon		Iron	
		Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent
Wash metal	984.52	19.69	2.00	3.94	0.40	2.66	0.27	1.97	0.20	956.95	97.20
Scrap	984.52	1.97	0.20	3.94	0.40	0.30	0.03	0.49	0.05	977.63	99.30
Total	1969.04	21.66	...	7.88	...	2.96	...	2.46	...	1954.58	...
Final steel	2000	4.00	0.20	4.00	0.20	0.60	0.03	1.00	0.05	1990	99.50
Amount oxidized	.....	17.66	...	3.88	...	2.36	...	1.46	...	—55	...
Oxygen required	35.93	25.90	...	1.13	...	3.05	...	1.66	...	4.19	...

Material	Total, lb	CaO		MnO		P_2O_5		SiO_2		FeO		MgO		Oxygen	
		Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent
Lime	52.7	51.65	98.00	...	...	...	...	1.05	2.00	...	...	...	...	...	...
Sand	8.16	...	...	...	...	...	...	8.16	100.00	...	...	...	...	...	...
Ore	120.1	1.20	1.00	1.20	1.00	0.18	0.15	6.00	5.00	...	...	...	...	28.82	24.00
Charge	...	...	...	5.01	...	5.41	...	3.12	...	...	...	7.06	...	8.86	(0.90 per cent in scrap)
Slag	117.7	52.85	44.90	6.21	5.28	5.59	4.75	18.33	15.57	18.83	16.00	7.06	6.00	...	...
Total oxygen supplied	...	...	...	...	...	...	...	...	...	...	...	...	...	37.68	...

TABLE XV

60 Per Cent Wash Metal, Electric Furnace Material Balance

Material	Total, lb	Carbon		Manganese		Phosphorous		Silicon		Iron	
		Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent
Wash metal	1175.09	23.50	2.00	4.70	0.40	3.17	0.23	2.35	0.20	1142.19	97.20
Scrap	783.39	1.57	0.20	3.13	0.40	0.24	0.03	0.39	0.05	777.91	99.30
Total	1958.48	25.07	...	7.83	...	3.41	...	2.74	...	1920.10	...
Final steel	2000	4.00	0.20	4.00	0.20	0.60	0.03	1.00	0.05	1990	99.50
Amount oxidized	.....	21.07	...	3.83	...	3.21	...	1.74	...	—70	...
Oxygen required	42.51	30.90	...	1.15	...	4.14	...	1.98	...	4.44	...

Material	Total, lb	CaO		MnO		P_2O_5		SiO_2		FeO		MgO		Oxygen	
		Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent
Lime	55.8	54.68	98.00	...	...	...	...	1.16	2.00	...	...	...	...	...	...
Sand	6.69	...	...	...	...	...	...	6.68	100.00	...	...	...	...	...	...
Ore	148.3	1.48	1.00	1.48	1.00	0.22	0.15	7.42	5.00	...	...	...	...	35.59	24.00
Charge	...	...	...	4.98	...	7.35	...	3.72	...	...	...	...	...	7.05	(0.90 per cent in scrap)
Slag	124.7	56.16	45.03	6.46	5.18	7.57	6.07	18.98	15.22	19.95	16.00	7.48	6.00	...	...
Total oxygen supplied	...	...	...	...	...	...	...	...	...	...	...	...	...	42.64	...

TABLE XVI

70 Per Cent Wash Metal, Electric Furnace Material Balance

Material	Total, lb	Carbon		Manganese		Phosphorous		Silicon		Iron	
		Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent
Wash metal	1363.58	27.27	2.00	5.45	0.40	3.68	0.27	2.73	0.20	1325.40	97.20
Scrap	584.39	1.17	0.20	2.34	0.40	0.18	0.03	0.29	0.05	580.30	99.30
Total	1947.97	28.44	...	7.79	...	3.86	...	3.02	...	1905.70	...
Final steel	2000	4.00	0.20	4.00	0.20	0.60	0.03	1.00	0.05	1990	99.50
Amount oxidized	...	24.44	...	3.79	...	3.26	...	2.02	...	—84	...
Oxygen required	48.60	35.85	...	1.10	...	4.21	...	2.30	...	5.14	...

Material	Total, lb	CaO		MnO		P_2O_5		SiO_2		FeO		MgO		Oxygen	
		Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent	Lb	Per cent
Lime	64.5	63.21	98.00	...	...	...	...	1.29	2.00	...	...	...	...	...	....
Sand	6.05	...	...	...	...	...	...	6.05	100.00	...	...	...	...	...	....
Ore	181.3	1.81	1.00	1.81	1.00	0.27	0.15	9.07	5.00	...	...	...	...	43.51	24.00
Charge	...	...	...	4.89	...	7.47	...	4.32	...	...	...	...	...	5.26	(0.90 per cent in scrap)
Slag	144.2	65.02	45.09	6.70	4.65	7.74	5.37	20.73	14.37	23.07	16.00	8.65	6.00	...	....
Total oxygen required	...	...	...	...	...	...	...	...	...	...	...	...	...	48.77	....

DISCUSSION

PRESENTED BY

STEPHEN VAJDA, Staff Engineer — Steelmaking, Office of Chief Engineer, Jones and Laughlin Steel Corp., Pittsburgh, Pa.

E.C. WRIGHT, Head, Department of Metallurgical Engineering, University of Alabama, University, Ala.

Stephen Vajda: Mr. Wright is to be commended for his very thorough analysis of this unique tool that is available to the steel industry. One can find very little to discuss in his approach of the problem or in his theoretical calculations. There are several questions, however, which I would like to raise in the operating and cost analysis portions of his paper.

For example, in Table II, he is using Mr. King's figure of 19.15 tons per hour production for a 225-ton furnace using 50 per cent hot metal. At Jones & Laughlin's Pittsburgh Works, we have eleven 275-ton furnaces which are averaging 26.6 tons per hour with 50 per cent hot metal and 25.5 tons per hour with 45 per cent. This equals Mr. Wright's 25 tons per hour with 50 per cent washed metal.

An operating problem which would be a little difficult to overcome is when to stop blowing. Are there any special characteristics to the 3 per cent C, 0.2 per cent silicon end point? Does the silicon and carbon go down in the same ratio? What happens when both vary from one tap to another? Could one pre-determine the total oxygen to be used based on the carbon analysis and after this is used, pour the metal?

From Mr. Wright's article, it seems that the only way to make the washed hot metal is by a basic converter. This raises the question in existing plants as to available location. If the metal has to be hauled any distance at all, how much of the heat from the washed metal will be actually available?

Also, the furnaces will not take the washed metal as fast as it is blown. Would he propose to hold it in submarine ladles or a mixer? This means reladling. Everytime hot metal is reladled it loses at least 100 F of temperature. These heat losses will dissipate the advantages of washed metal over hot metal.

In his summary, Mr. Wright estimates the cost of the required facilities, including a 100-ton oxygen plant, to be $3,000,000. This seems ultra conservative since the oxygen plant alone would cost $1,500,000. All the facilities required for a top-blown oxygen converter shop will be required except the scrap and flux addition facilities and the teeming platform. To blow the stated 150 tons per hour would require two vessels, since the 30-ton converter would require a blow every 12 minutes. With all the above facilities, one might as well go the entire way and install an oxygen blown converter plant.

A more practical approach might be the installation of a station near the mixer complete with lance and smoke hood. After the iron has been poured out of the mixer into the iron ladle, it could be placed on a stand at this station, the lance lowered and oxygen blown for a predetermined time. This also has its disadvantages in that the slag would have to be skimmed off before charging into the furnace, a messy job at best.

The Japanese may have the eventual answer — blow oxygen directly into the blast furnace hearth before tapping. It will be interesting to follow their results. The use of oxygen in the runners in this country has proven unsatisfactory.

E. C. Wright: Refer to Figure 4, the production rates for a 275-ton furnace of 26.6 tons per hour is just what would be expected for normal hot metal heats. This rate is in line with King's figure of 19 tons per hour and Green's figure of 22 tons per hour for a 225-ton furnace using hot metal charge. This checks our formula where the relation between furnace size and melting rate per hour on hot metal heats. If a 50 per cent wash metal were substituted for 50 per cent hot metal in Mr.

Vajda's 275-ton furnace, we would expect a production of 38 tons per hour.

There should be little difficulty in determining when to stop blowing in order to accomplish desiliconizing. The amount of oxygen required for oxidation of manganese and silicon in the first stage could readily be calculated and an efficiency of 90 per cent expected. The determination of the end point would be based on blowing a definite amount of oxygen. As stated in the paper, the 3 per cent carbon level or desiliconizing was selected to eliminate as much as possible the carbon boil and the turbulence and flame associated with this reaction. The author did not intend in his paper to indicate that desiliconizing could only be accomplished in a basic converter. The intent of this statement was to reflect that desiliconizing could probably be best accomplished in a basic converter. Whatever equipment is used for desiliconizing should be in close proximity to the open hearth furnaces. Wash metal should only be produced as needed for open hearth charging; hot metal should be stored in the mixer as in normal practice on hot metal heats.

The cost of installation for one 30-ton converter for desiliconizing plus a 100-ton per day oxygen plant should not exceed $3,000,000. It has been reported that the McLouth Steel Plant with three converters, a 165-ton per day oxygen plant, plus buildings and accessory equipment had a total cost of seven million dollars. One 30-ton vessel could easily produce 150 tons of wash metal per hour, since the blowing period is only three minutes instead of 12 minutes as stated by Mr. Vajda. A total blowing cycle of six minutes for charging, blowing, and pouring the wash metal should be accomplished and over 150 tons per hour could easily be obtained in one 30-ton converter.

AUTOMATIC CONTROL IN THE STEEL INDUSTRY*

▲ AUTOMATION is a new, popular, and imagination-stirring word that is being "hawked" as something new under the sun, when in reality it is the evolutionary trend of the United States' industrial economy to ever-improving the technical application of power or energy, mechanization and automatic control to industrial production. It is the evolvement of continuous production methods as contrasted to batch single operation methods with as many automatic self-directing and self-inspecting features as may be economically justified.

There are four phases of industrial advance included in the popular concept of automation:

1. The automation of the metal-working industry involving mechanized and automatic transfer machines between automatic machine tools, with self-directing and self-inspecting features.
2. The automatic control of industrial processes through the use of electronic equipment such as controls, regulators, analog computers, and gaging devices.
3. The automatic control of manufacturing processes through the use of automatic control systems that embody self-correcting feedback regulating systems.
4. Office or clerical mechanization utilizing the high-speed computer and associated machines.

The advance to continuous automatic production in the metal-working industry during the late 40's to the present is called automation; however, the steel industry adapted these same methods to manufacture of steel products many years ago when the modern primary slabbing and blooming mills were developed, and at present two men in an air-conditioned pulpit control at least 20 to 25 motors totalling up to 19,000 hp.

The change in flat products manufactured in the late 20's and early 30's from sheet bar and individual sheet processing to continuous methods using coiled strip was as significant an advance as the Detroit-type automation.

However, the steel industry, though well advanced in some major production areas, has lagged in this trend toward advanced mechanization and continuous, automatically controlled processing in some areas—namely, many of our finishing and materials-handling operations.

Until recent years the quality of steel products, and to a lesser degree the rate of production, depended largely upon the skill and judgment of the individual. Identical machines varied in productivity. Quality of product likewise varied in about the same degree as the skill of individual operators. A change is now taking place and production of many steel products is becoming more of a science and less of an art. It is in this general area, perhaps, where automation may have the greatest impact upon any industry.

A few important principles to observe in the development of automatic manufacturing in the steel industry.

1. In order to make real gains in automatic manufacturing development, it is sometimes necessary to rethink the process, or the machine, or the product.
2. In developing automation, it is important to slant one's thinking along the lines of continuous process methods rather than a batch process.
3. It is often necessary to change the character of the piece in process to accomplish automation.
4. Tradition and years of know-how as a background are occasionally a hazard to successful automation. This new manufacturing concept requires that we question every phase of a process or product; rethink in terms of continuous production.
5. The closed-loop self-correcting regulating system is a major tool in the development of automatic manufacturing methods.
6. Automation by imitating a man's movements and operational actions is bound to be expensive or doomed to failure. The process and equipment must be redesigned along the lines adaptable to today's new tools.
7. Tomorrow's machines are going to more complex. Maintenance and preventive maintenance policies are going to have a greater effect on manufacturing cost than in the past.

*Abstracted from paper by R. W. Holman, Assistant Vice President, Research and Technology Division, United States Steel Corp., Pittsburgh, Pa., presented at Birmingham Regional Meeting of the American Iron and Steel Institute, October 5, 1955.

W. H. Collison

PRESIDENT, 1956

ASSOCIATION OF IRON AND STEEL ENGINEERS

W. H. COLLISON, plant superintendent, blast furnaces and coke works, Great Lakes Steel Corp., Ecorse, Mich., graduated in 1926 from the University of Cincinnati with a degree in chemical engineering. His course at the university was a cooperative one in which he worked part of the time in the coke plant of Crucible Steel Co. during two years prior to his graduation. Upon graduation, he continued services at this plant until 1927 when he went to work for the Central Alloy Steel Corp. at Massillon, Ohio, as a heater in the coke plant. He was soon promoted to turn foreman. His next job was with the Pure Oil Co., in Marcus Hook, Pa., as a chemist. When Great Lakes Steel Corp.'s new coke plant went into operation Mr. Collison went to Detroit as a boss heater. He progressed rapidly through the steps of assistant superintendent and superintendent of the coke works, and ultimately blast furnaces, to his present position.

The President's Message

We enter the year 1956 in a period of high prosperity, fraught with problems of increasing population and expanding business activity.

In the steel industry, problems of production schedules, of quality, of maintenance, of costs, of raw materials, of plant expansion and of developing men with steelmaking know-how are subjects of discussion wherever steel men meet.

There is need to develop the new technical graduate, but with the shortage of such men it is also imperative that the latent abilities of the man without technical training be developed. With a program of activities designed to advance the engineering and operating practices of the industry, the Association of Iron and Steel Engineers has before it, in these circumstances, an opportunity, a challenge and a duty.

It is my belief that the office to which you have elected me should be regarded as an opportunity to serve — to serve both the membership and the industry. I must depend upon the entire membership, committee men and officers, to give your support generously as you have in the past.

We look forward to a most active year of the Association.

W. H. COLLISON

President, AISE

JAMES D. O'ROARK
First Vice President

LEONARD LARSON
Second Vice President

EMIL KERN
Treasurer

NEWLY ELECTED OFFICERS AND DIRECTORS

JAMES D. O'ROARK was born in Broadway, Va. He was graduated from Ohio State University in 1926 with a degree in electrical engineering. After graduation he was employed in the student engineering training course and test floor from 1926 to 1930 at Westinghouse Electric Corp.'s East Pittsburgh works. He has been employed by Weirton Steel Co. from 1931 to the present date as electrical field engineer, electrical foreman of strip steel and sheet mill dept., assistant electrical superintendent, electrical superintendent, and assistant manager of service and maintenance, electric, the position he now holds.

LEONARD LARSON was employed as a draftsman at Jones & Laughlin Steel Corp., and Carnegie Steel Co. in Pittsburgh, Pa. from 1913 to 1917 while attending night school at Carnegie Institute of Technology. In 1917 he moved to Massillon, Ohio as a draftsman for Central Steel Co. He was appointed chief draftsman in 1918, and assistant chief engineer for Central Alloy Steel Corp., in 1926 in a merger between Central Steel Co., and United Alloy Steel Corp. In 1929 he was appointed chief engineer, and served in this capacity for Central Alloy Steel Corp., and Republic Steel Corp., after a merger in 1930 until 1939 when he was transferred to the Cleveland district as district chief engineer, the position he now holds. From 1933 to 1936 he spent about one year on special open hearth work for the corporation, and about two years in the operating department as divisional superintendent at the Massillon steel plant.

EMIL KERN was graduated from the University of Stuttgart, Germany in 1926 and began his career as a machinist and designer with Mesta Machine Co. in 1930. He became associated with Reynolds Metals Co., as chief mechanical engineer in 1945, and joined the Allegheny Ludlum Steel Corp., Pittsburgh, Pa., as chief engineer the following year. In May 1949, he was elected a vice president in charge of engineering of the Allegheny Ludlum Steel Corp.

S. C. READ attended Purdue University and the University of Michigan. He graduated from the University of Michigan with a degree in mechanical engineering, and later received a master's degree in metallurgical engineering at Carnegie Institute of Technology. Mr. Read started to work for Jones & Laughlin Steel Corp., Pittsburgh, Pa., in 1924 as assistant superintendent, power department at the South Side works. In 1938, he was made master mechanic of rolling mills, Pittsburgh works. He was appointed superintendent of blooming department and rolling mills, Pittsburgh works in March 1946, and named manager of maintenance for the entire corporation in November 1947. Mr. Read has since been made director, construction and maintenance for Jones & Laughlin Steel Corp.

C. E. PRITCHARD was born in Pittsburgh, Pa. and was graduated from Carnegie Institute of Technology in 1932. He first worked for the Atlantic Refining Co. where he stayed until 1937 at which time he entered the steel industry. He then became employed in mill maintenance at the Warren district of Republic Steel Corp., with later appointment as district lubrication engineer. In 1941 he was promoted to chief lubrication engineer of all Republic Steel's operations with headquarters in the general office in Cleveland. In 1951 he joined the Alan Wood Steel Co., serving as superintendent of finishing mills and the following year was promoted to superintendent of mills, including all rolling mills and a cut nail mill, the position he now holds.

NELSON L. ARMITAGE was born in Bergholz, Ohio and attended schools in Steubenville, Ohio. He was first employed at Follansbee Brothers in Follansbee, W. Va. He next spent twenty-one years with Wheeling Steel Corp. in Steubenville, Ohio, working on the bar mill and soaking pits. He went with Granite City Steel Co. in May 1951 as soaking pit foreman. His present position is assistant superintendent of blooming mill.

C. E. DUFFY was born in Baldwinsville, N. Y., and after completing high school attended Clarksons College of Technology where he received a B.S. in mechanical engineering. In June 1926, he entered the Bethlehem Steel Corp.'s loop training course at Bethlehem, Pa., and in September of the same year was transferred to the fuel department of Bethlehem's Sparrows

S. C. READ
Secretary

C. E. PRITCHARD
Director-at-Large

N. L. ARMITAGE
Director

C. E. DUFFY
Director

D. N. EVANS
Director

G. A. HENDERSON
Director

ASSOCIATION OF IRON AND STEEL ENGINEERS 1956

Point plant to assume the duties of testman. He became the assistant fuel engineer of the fuel department in 1930, and fuel engineer in 1948.

D. N. EVANS was born in Milwaukee, Wisc., and was graduated in 1935 from the University of Oklahoma with a B.S. degree in mechanical engineering. He became employed by the Inland Steel Co. that same year as a machine shop foreman, and in 1939 was made plant lubrication engineer and remained in that capacity until 1947. From 1947 to 1952 he served as assistant superintendent of the mechanical department. In 1952 he was transferred to the field forces department as assistant superintendent, and serves in this capacity at the present time.

GEORGE A. HENDERSON was graduated from Carnegie Institute of Technology with a B.S. degree in mechanical engineering in 1922, and received his M.S. degree in combustion engineering in 1923. He began his working career with Bethlehem Steel Co., that same year as an inspector in the Lackawanna plant. The various positions he has held there include jobs in the blooming mills, rail, structural and bar mills. His present position is superintendent of mills division.

HAROLD C. HOEFT was born in 1915, in Pontiac, Mich. He was educated in the Detroit Public Schools and studied electrical engineering while attending Wayne University. He started his employment with Great Lakes Steel Corp., in 1935, working in the electrical construction and electrical maintenance departments. In 1941, he was transferred to the electrical engineering department, and the promotion to his capacity of assistant chief electrical engineer was made in 1947. He moved to Great Lakes' subsidiary, the Stran Steel Products Co., in Oklahoma City, Okla., in 1955, and holds the position there of district manager.

JAMES N. IMEL was born at Cambridge Springs, Pa. in the year 1907. He received his elementary and high school education in Cleveland, Ohio and was graduated from Bethany College, Bethany, W. Va. in June 1930. He started to work with the Jones & Laughlin Steel Corp., shortly after his graduation as a student trainee. After holding various jobs in the rolling mills department, he was advanced to the position of general foreman, D. S. mills in 1937. In April 1946, he was promoted to the position of assistant superintendent of rolling mills, and on August 1, 1947 was appointed superintendent of rolling mills, Pittsburgh works. He is now superintendent, continuous sheet and strip department, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

W. W. JUSTICE, a Pittsburgher by birth, attended Carnegie Institute of Technology, receiving an M.S. degree in mechanical engineering in 1933. He then started work at United States Steel Corp.'s Duquesne works as a power and fuel engineer, transferred to the Pittsburgh office as an industrial engineer in 1937, and became a project engineer in the Youngstown district in 1941. In the spring of 1943 he went into operations, successively being responsible for operation of the narrow gage, service and operating maintenance departments. In 1952 he was appointed assistant division superintendent of the blast furnaces, and in 1953 chief engineer, Youngstown district. His present capacity is superintendent operating maintenance at that plant.

N. R. KIRKDOFFER was born in 1903 at Milford, Ind. He graduated from Purdue University in 1928 with a B.S. in electrical engineering. He was hired at Inland Steel Co. in June, 1928 as a test engineer in the electric and power departments. He advanced to electrical foreman in 1931 and to assistant general foreman in 1944. In 1946 he was promoted to assistant superintendent of the electric and power departments, and in 1947 to assistant superintendent of the electric, power and steam departments. In 1950 he was promoted to superintendent of the power and steam departments.

A. J. F. MacQUEEN was born in Thessalon, Ontario and received his grade and high school education in Sault Ste Marie. He was graduated in 1925 from the University of Toronto with a B.S. degree in electrical engineering. He began his working career with General Electric Co., in Schenectady where he spent two years on their test course. The following nine years were

HAROLD C. HOEFT
Director

J. N. IMEL
Director

W. W. JUSTICE
Director

N. R. KIRKDOFFER
Director

A. J. F. MacQUEEN
Director

W. A. MARSHALL
Director

EMMET A. MAYHALL
Director

E. C. McDONALD
Director

spent with Sharon Steel Corp., where he started as a clerk in the electrical department and eventually became assistant electrical superintendent. He then joined Republic Steel Corp., for one year of construction engineering at their South Chicago plant. He returned to Canada in 1942 where he worked with Atlas Steels in Welland, Ontario as superintendent of maintenance. In 1947 Mr. MacQueen became employed by Algoma Steel Corp. as electrical superintendent, then maintenance superintendent, and then was promoted to his present capacity of chief electrical engineer.

W. A. MARSHALL, a native of Pennsylvania, graduated from Penn State in 1915. He started with United States Steel Corp. (American Sheet and Tin Plate) in 1916. Since then he has been in engineering and maintenance work at New Castle, Wellsville, New Kensington, Vandergrift and Irvin. He went to Columbia-Geneva Steel Division of the United States Steel Corp. in 1948. He is now works engineer at the Pittsburg, Calif. works.

EMMETT A. MAYHALL was born in Double Springs, Ala., educated in public schools of Alabama and Tennessee, and was graduated from the University of Cincinnati in 1929 with a degree in electrical engineering. Upon graduation he was employed by the Cincinnati Street Railway Co., in the sub-station and research departments. In 1936 he joined the Tennessee Coal and Iron Division of the United States Steel Corp., as a draftsman in the electrical engineering department, and subsequently became checking engineer. As a reserve officer, he was called to active duty in 1942, served four years and was returned to inactive duty with the rank of lieutenant-colonel. He is now employed as an electrical engineer in the electrical engineering department of the Tennessee Coal and Iron Division of the United States Steel Corp.

E. C. McDONALD received his elementary schooling in Duquesne, Pa., and was graduated from the University of Pittsburgh in 1922 with a degree in metallurgical engineering. His first position after graduation was with Carnegie Steel Co., in Duquesne, as a test engineer. In 1926 he accepted the position of assistant combustion engineer of Donner Steel Co. in Buffalo, N. Y. Donner Steel was combined with Republic Steel Corp., in 1930, and shortly thereafter, Mr. McDonald was made Buffalo district combustion engineer. When Corrigan-McKinney Steel Corp. was merged with Republic, in 1935, he was transferred to Cleveland as chief combustion engineer of that works. In 1955 he was promoted to the position of assistant chief combustion engineer and has recently been made chief combustion engineer of Republic Steel Corp.

F. R. PULLEN received his degree of Bachelor of chemical engineering from Ohio State University in 1937. Upon graduation he was employed by Bethlehem Steel Co., and assigned to the loop course. His first job was instrument repairman in the fuel department at the Sparrows Point plant. He was then promoted through the following positions: testman, testman foreman, assistant combustion engineer, combustion engineer and assistant fuel engineer. On January 1, 1949 he became fuel engineer at the Johnstown plant of Bethlehem Steel, which position he now holds.

ROBERT SERGESON was born in Philadelphia, Pa., and was graduated from University of Pennsylvania in 1922 with a B.S. in chemical engineering. He entered the employ of the Central Steel Co., Massillon, Ohio, working in the metallurgical laboratory and subsequently in open hearth, soaking pits and bar mills. He remained with this company after its merger into Central Alloy Steel Co., and later into Republic Steel Corp., being in charge of the metallurgical laboratory for eight years. In 1938, Mr. Sergeson joined the Park works of the Crucible Steel Co. of America, Pittsburgh, Pa., as chief metallurgist, remaining untill 1945, when he became chief metallurgical engineer of Rotary Electric Steel Co., Detroit, Mich.

F. T. VAN CAMP was born and educated in Syracuse, N. Y. He attended Syracuse University and later took Syracuse and Cornell extension courses. His first place of employment was for the John Deere Plow Co. in Syracuse, followed by employment at the New York Power Corp., and then by the Halcomb Division of Crucible Steel Co. of America. In 1943 he went to work as general foreman of rolling mills at Wickwire Spencer Steel Division of the Colorado Fuel and Iron Corp., and in 1948 he was promoted to superintendent, rolling mills, which position he now holds.

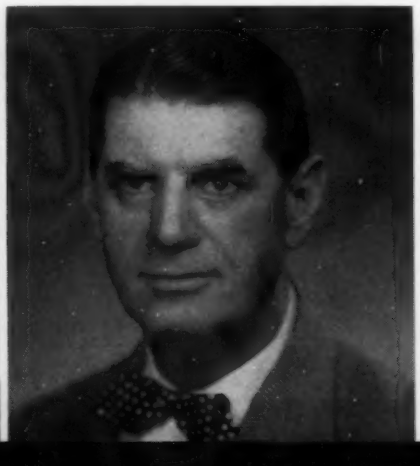
J. B. WHITLOCK was born in Piqua, Ohio. He was graduated from the Piqua high school in 1914 and spent the following two years attending Miami University in Oxford, Ohio and in 1917 was a special student at the Ohio State University in Columbus, Ohio. He then served two years with the U.S.N.R.F., and upon release from active duty in 1919, he returned to Columbus, Ohio as power engineer. He went to work for Armco Steel Corp., in 1922 holding the following jobs: assistant superintendent power at the Middletown works, superintendent maintenance, then works engineer at Zanesville, Ohio, and in 1933 became chief maintenance engineer again at the Middletown works. He holds this position at present.

F. R. PULLEN
Director

ROBERT SERGESON
Director

F. T. VAN CAMP
Director

J. B. WHITLOCK
Director



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S. C. READ, *Director, Construction and Maintenance*, Jones and Laughlin Steel Corp., Pittsburgh, Pa.

CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

Monday, February 27, 1956 — Cocktail Hour and Dinner 6:30 P.M., Meeting 8:00 P.M.

"High Voltage High Interrupting Capacity Controllers," by C. A. Lister, Assistant Supervisor of the Laboratory, Electric Controller and Manufacturing Co., Cleveland, Ohio.

Thomas Jefferson Hotel, Birmingham, Ala.

BUFFALO SECTION

Tuesday, February 14, 1956 — Dinner 6:30 P.M., Meeting 8:00 P.M.

"Construction and Application of Draft Recorder on the 44-In. Bloom Mill," by N. S. Wells, Application Engineer, Electrical Dept., and G. Sibankin, Development Metallurgist, The Steel Company of Canada, Ltd., Hamilton, Ontario, Canada.

Hotel Sheraton, 715 Delaware Avenue, Buffalo, N. Y.

CHICAGO SECTION

Tuesday, February 7, 1956 — Dinner 6:30 P.M., Meeting 7:45 P.M.

"The Use of Radioactive Isotopes in Industry," by Dr. C. E. Crompton, Assistant Director of the Isotopes Div., Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tenn.

Phil Smidt's Restaurant, 1205 N. Calumet Avenue, Hammond, Ind.

CLEVELAND SECTION

Tuesday, February 21, 1956 — Dinner 6:30 P.M., Meeting 8:00 P.M.

"Your Future in Cleveland as a Seaport," by W. R. Rogers, Port Director, City of Cleveland, Cleveland, Ohio; Robert C. Hienton, Vice President, Cleveland Electric Illuminating Co., Cleveland, Ohio; and H. A. Jones, Assistant Chief Cost Accountant, Republic Steel Corp., Cleveland, Ohio.

University Club, 3813 Euclid Avenue, Cleveland, Ohio.

DETROIT SECTION

Wednesday, February 15, 1956 — Dinner 6:30 P.M., Meeting 8:00 P.M.

"Detroit Edison Night."

"Modern Steel Mill Communications Systems — Industrial TV — 2-Way Radio," by N. C. Youngs, Assistant General Sales Manager, Michigan Bell Telephone Co., Detroit, Mich.

Dinner — Cafeteria, General Office Building, Detroit Edison Co., Detroit, Mich. Meeting — Sales Auditorium, Service Building, Detroit Edison Co., Detroit, Mich.

LOS ANGELES SECTION

AISE Western Meeting, February 20, 21, 22, 1956.

Hotel Statler, Los Angeles, Calif.

PHILADELPHIA SECTION

Saturday, February 4, 1956 — Dinner 6:00 P.M., Meeting 7:00 P.M.

"Methods of Desulphurization of Coke Oven Gas," by J. M. Graubard, Supervisor of Design, Coke Plant, United States Steel Corp., Fairless Hills, Pa.

"Conversion of Automotive and Industrial Engines to L. P. Gas," by P. F. Walker, Mechanical Engineer, Service Division, Bethlehem Steel Co., Bethlehem, Pa.

Engineers' Club, 1317 Spruce St., Philadelphia, Pa.

PITTSBURGH SECTION

Monday, February 13, 1956 — Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Vacuum Melting of High Alloy Steels at Allegheny Ludlum Steel Corp.," by W. W. Dyrkacz, Manager of Quality Control, Allegheny Ludlum Steel Corp., Watervliet, N. Y.

Alumni Room, University Club, University Place, Pittsburgh, Pa.

ST. LOUIS SECTION

Wednesday, February 22, 1956 — Meeting 6:30 P.M.

"Manufacture and Laying of Cable," — Film and short talk.

Mineral Springs Hotel, Alton, Ill.

SAN FRANCISCO SECTION

AISE Western Meeting, February 20, 21, 22, 1956.

Hotel Statler, Los Angeles, Calif.

YOUNGSTOWN SECTION

Monday, February 27, 1956 — Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Building Management Cooperation," by Joe Kopas, Training Counselor, Republic Steel Corp., Cleveland, Ohio.

Mahoning Country Club, Girard, Ohio.

Electrical Equipment for Auxiliary Drives of hot strip mills Part I

By S. H. WILLIAMSON
District Manager — Application Engineering
General Electric Co.
Pittsburgh, Pa.

. . . . this is Part I of a three-part article which will appear in successive issues of the Iron and Steel Engineer . . . . *with the heavy investment which is required by a continuous mill, careful selection of equipment for the auxiliaries is necessary for economical operation of such mills . . . .*

▲ PRESENT-DAY auxiliary drives are expected to perform functions as important as the main drives in the production of hot strip. Faulty operation of a single table section or a coiler can, for example, limit or stop production as surely as can the failure of a main drive motor. There are many auxiliaries, and the operation of each must be closely coordinated with that of the mill. Each must respond readily to the wishes of the operator. Therefore, it is very important that proper engineering attention be given every one of the auxiliary drives to insure the utmost in hot strip tonnage.

The main purpose of this article is to review what today is considered good practice in the selection of motors and control for these drives. In so doing, some of the special requirements of the various drives will be considered together with engineering reasons for selecting their particular motors and control.

SCOPE

Figure 1 is a schematic layout of a typical continuous hot strip mill. Beginning with the slab pushers at the furnaces, there are in the continuous mill such drives as furnace delivery tables, roughing mill tables, table side guards, roughing mill screwdowns, delay or "intermediate" table, finishing mill approach table, crop shear, finishing mill screwdowns, loopers, flying shear, runout tables, coiler table side guides, pinch rolls at coilers, coilers, coil conveyor and also the piler for the strip which has been cut to length by the flying shear. The typical semi-continuous hot strip mill has a reversing rougher with edger in place of the four or five roughing mill motors. The screwdown and reversing table drives associated with such a reversing rougher will, together with the above mentioned auxiliary drives, constitute the subject matter of this article—presented in three parts.

Part I deals with types of motors, their characteristics and construction, basic types of control, d-c power supplies, thickness and width gages, etc. Specific drives are discussed in Parts II and III.

D-C MOTORS

Mill auxiliary type motors (Figures 2 and 3) are the accepted standard on all drives—space permitting. Motor dimensions, including shaft sizes, torque ratings, etc., have been standardized by AISE; and liberal design requirements enable these motors to withstand the severest mechanical and electrical abuse.

Among the outstanding mechanical features are the heavy cast steel frames, large shafts and heavy duty dustproof grease-sealed roller bearings. Momentary load capacities (commutating abilities) are considerably above those of conventional industrial type motors. Armature WK^2 values are kept low in the interests of responsive performance. While class B insulation has been used on fields and armatures, a class H system has been developed and is now used on all motors of this type supplied by the author's company.

A standard 230-volt, shunt-wound, or stabilized shunt-wound, mill motor can operate at twice rated volts (460 volts) applied to its armature and deliver rated torque and twice rated nameplate horsepower. A 100-hp, 485-rpm, 230-volt motor can, for example, be operated at 970 rpm and deliver 200 hp without exceeding rated temperature rise. In fact, such motors can be applied on a constant torque load basis to operate on voltages as high as 600, although they cannot be expected to carry high momentary overloads at those voltages. Inasmuch as d-c shop power distribution is usually at 230 or 250 volts, it is not possible to capitalize on this overvoltage capacity of the motors when constant-potential controlled on shop power. Adjustable

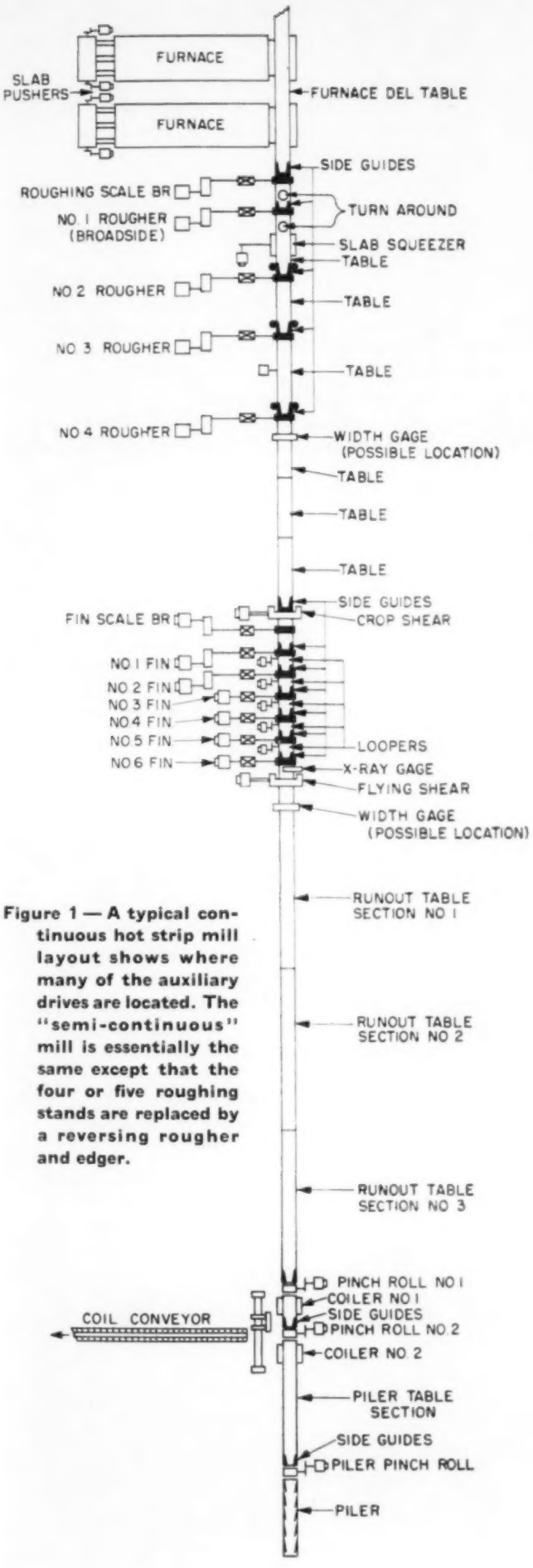


Figure 1 — A typical continuous hot strip mill layout shows where many of the auxiliary drives are located. The "semi-continuous" mill is essentially the same except that the four or five roughing stands are replaced by a reversing rougher and edger.

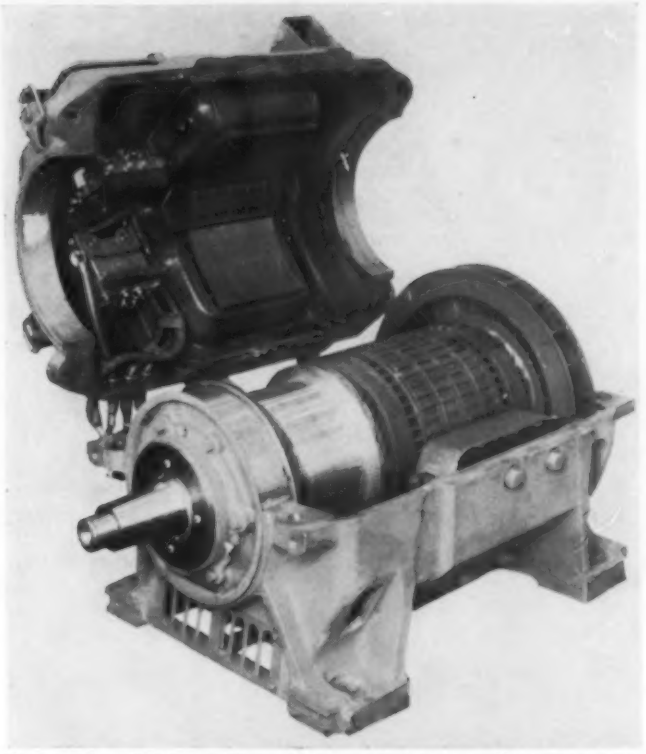


Figure 2 — Mill auxiliary type motor is usually rated on a 1-hr, 75 degrees C rise basis. It is applicable to most intermittent duty type of jobs. Removable and hinged type covers simplify inspection and adapt the motor to several arrangements of forced or self ventilation when necessary. Air may be supplied through openings in the base as well as through those shown. Self-ventilation is seldom used on hot strip mills because of excessive dirt.

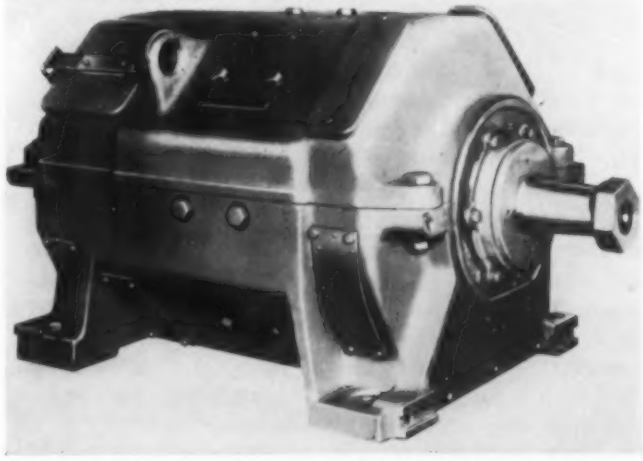


Figure 3 — Features of mill motor include such items as dust-proof, enclosed, solid cylindrical roller bearings, double tapered shaft extensions, special pads on frame and grooves in feet for brake mounting, Class B and/or Class H insulation, armature banding and commutator designed for high safe speeds, strong construction throughout for great mechanical strength.

voltage control systems can however take advantage of this motor feature now and then, since the designer of the drive is free to select any suitable voltage for the generators. Also standard 550-volt armatures may be used at low voltages to obtain low speeds for direct connection and driving of table rolls.

Common practice on steel mill auxiliary drives is to use either totally enclosed non-ventilated motors, or to

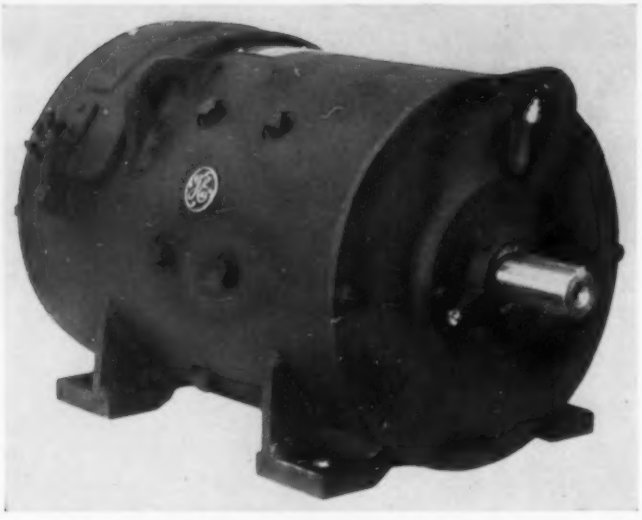


Figure 4 — This type d-c motor was developed for runout table service.

2. One-piece solid rolled steel frame with lifting lugs and sealed for water tightness.
3. Large commutator end handhole covers, quickly removable.
4. Class B insulation on armature and fields.
5. Cartridge-enclosed ball and roller bearings, and with labyrinth seals on shaft to prevent moisture from entering the bearings.
6. Low speed regulation.
7. Exceptional commutating ability and brush life—motors designed for frequently repeated torque peaks of five times rated torque.

There are many noteworthy features which, for lack of space, will be omitted in this article. The important fact is that these motors are designed specially to perform under the most trying conditions. Some of these conditions will be covered in detail in the runout table portion of this series articles.

Among all hot strip mill auxiliaries there may only be an occasional exception to the use of mill or special mill motors. One such exception is the flying shear, where on some recent installations a slow speed direct-connected compensated motor has been used.

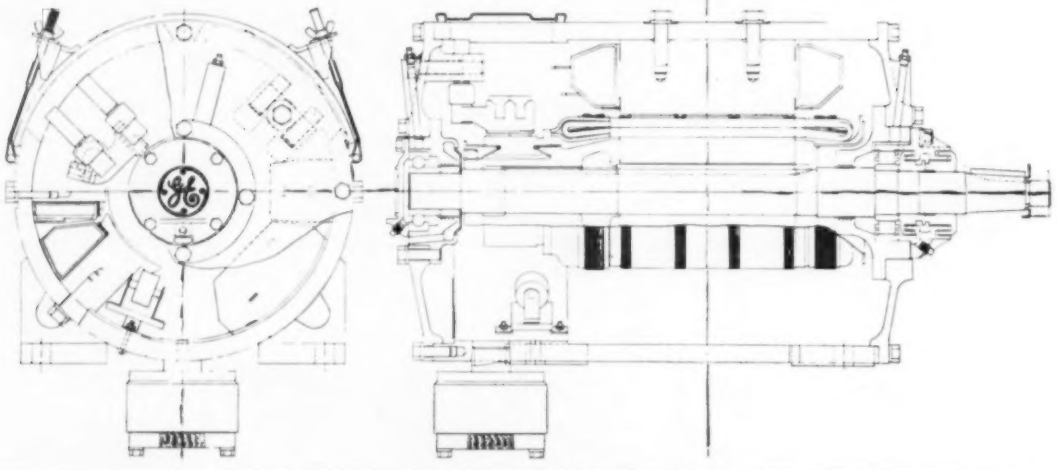


Figure 5 — Sectional views of d-c runout table motor.

provide force-ventilation where the totally-enclosed, non-ventilated motors may run hot for lack of ventilation. Non-ventilated motors are nearly always rated on a 75 degree C rise 1-hr basis. When force-ventilated they are rated to carry the same horsepower continuously. There are several ways to force-ventilate motors. Sometimes blowers with or without filters are mounted directly on the motors. Usually, however, filtered air is supplied from a separately mounted blower system through an opening in the motor base and leaves the motor through self-closing louvers to the mill area. Force-ventilation of motors is naturally to be avoided if possible; and, it is possible on most constant-potential controlled drives because the duty is of a very intermittent nature, motor torque being the primary requirement. Adjustable voltage drives are usually force-ventilated.

Small heavy duty motors of mill auxiliary construction have been developed for runout table and coiler service. See Figures 4, 5 and 6. These were first introduced with the advent of d-c runout table rollers. Roll spacings as low as 14.5 in. may determine the maximum diameters of such table motors. Some basic features of these motors are:

1. Mill type construction — totally enclosed non-ventilated.

D-C MOTOR CHARACTERISTICS

Speed and torque are the primary characteristics of a motor. They are the characteristics which define a

Figure 6 — This type d-c motor is used for coiler wrapper rolls.

TABLE I

230-Volt Speed, Torque and Horsepower Ratings of Mill Auxiliary Type Motors

Enclosed 1-Hour or Force-Ventilated Continuous

Size	Hp	Speed Full load rpm				Torque in lb-ft							
						Rated		Maximum starting			Maximum running		
		Series	Compound and *shunt	Adjusted speed (top)	Max. safe rpm	Series	Compound and *shunt	Series (500 per cent)	Compound (450 per cent)	*Shunt (360 per cent)	Series (400 per cent)	Compound (350 per cent)	*Shunt (300 per cent)
402	5	900	1025	2050	3500	29	25.5	145	115	92	116	90	75
602	7½	800	900	1800	3600	49	44.4	245	198	158	196	154	130
603	10	725	800	2000	3300	72	65.5	360	295	235	288	230	195
604	15	650	725	1800	3000	121	109	605	490	390	484	382	325
606	25	575	650	1950	2600	228	202	1140	910	730	912	710	600
608	35	525	575	1725	2300	350	320	1750	1440	1150	1400	1120	960
610	50	500	550	1650	2100	525	477	2625	2150	1720	2100	1670	1430
612	75	475	515	1300	1900	830	765	4150	3440	2750	3320	2700	2290
614	100	460	485	1200	1700	1140	1080	5700	4860	3890	4560	3780	3240
616	150	450	460	1150	1600	1750	1710	8750	7700	6150	7000 (390%)	6000	5130 (280%)
618	200	410	420	1050	1500	2560	2500	12800	11250	8500	10000	9000	7000

*Shunt or stabilized shunt wound.

motor as a motor. All motor job requirements must be expressed in these terms; and, that is why the information given in Table I is so essential to proper d-c motor selection.

As a further aid in understanding why a series-wound

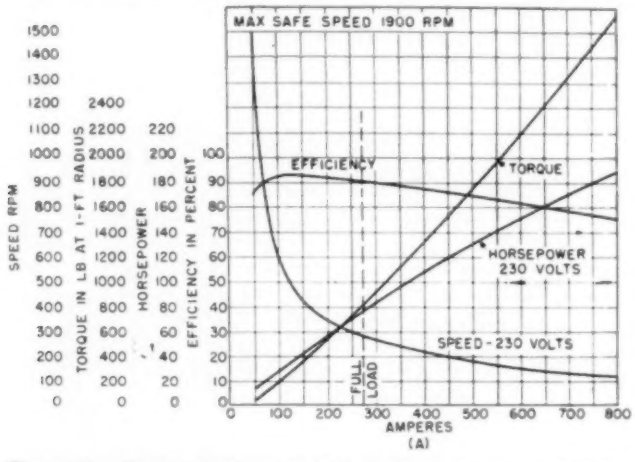
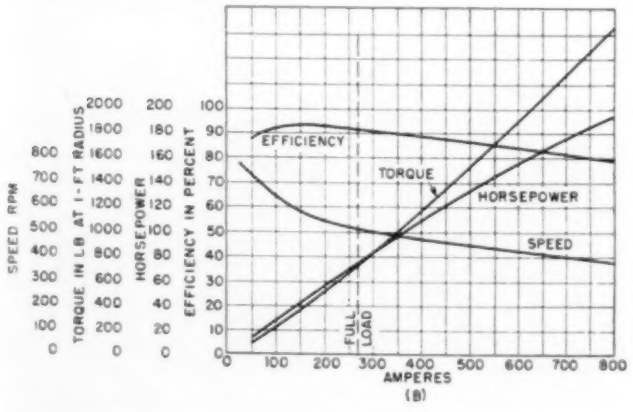


Figure 7 — Typical characteristics of a series wound 75-hp, 475-rpm, 230 d-c volts, 1-hr, totally enclosed, non-ventilated, mill auxiliary type motor.

Figure 8 — Typical characteristics of a compound-wound 75-hp, 515-rpm, 230 d-c volts, 1-hr, totally enclosed, non-ventilated, mill auxiliary type motor.



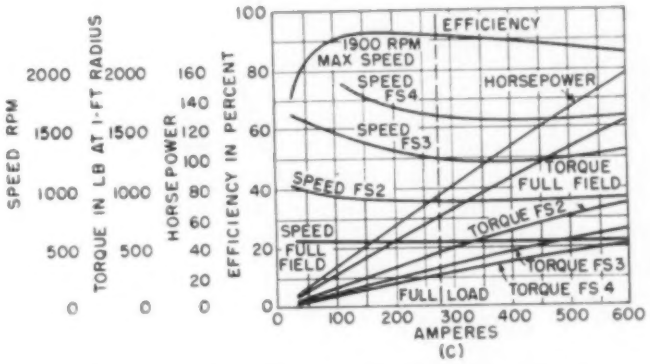
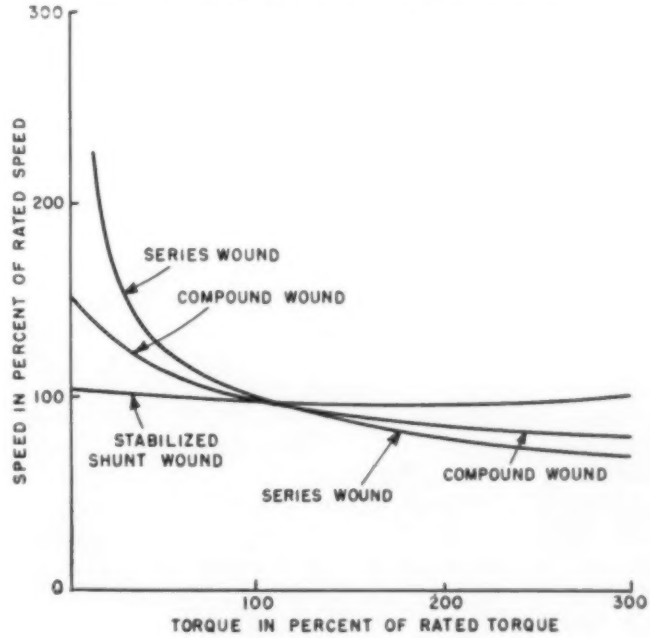


Figure 9 — Typical characteristics of a stabilized shunt-wound, 75-hp, 515-rpm, 230-d-c volts, 1-hr, totally enclosed, non-ventilated, mill auxiliary type motor.

Figure 10 — Speed vs torque characteristic curves are given for series-wound, compound-wound and stabilized shunt-wound mill auxiliary type motors.



motor is applied on one drive, a compound-wound motor on another and a shunt or stabilized shunt-wound motor on still another, Figures 7, 8, 9 and 10 are included for ready comparison of typical series, compound and shunt wound motors.

The electrical circuits of the series, compound, shunt and stabilized shunt wound motors are schematically given in Figure 11.

Sometimes it is well to regard motor characteristics in their fundamental relations to each other as expressed mathematically by equations 1, 2 and 2a:

Torque:

$$T = I_a \times \phi \times K_t \quad \ldots\ldots (1)$$

where:

T = torque at the motor air gap, usually expressed in lb-ft or in per cent of rated torque

I_a = armature current, usually expressed in amperes or in per cent of rated amperes

ϕ = net field flux (see Figure 12)

K_t = a constant determined by motor design and the units of T, I_a and ϕ

Armature current:

$$I_a = \frac{E_a - K_n \phi N}{R} \quad \ldots\ldots (2)$$

where:

E_a = motor armature volts — approximately equal to motor terminal volts

R = total ohms resistance in armature circuit

N = speed, usually expressed in rpm or per cent of rated speed

K_n = a constant determined by motor design and the units of I_a, E_a, N, ϕ and R

or, Armature current:

$$I_a = \frac{E_a - E_b}{R} \quad \ldots\ldots (2a)$$

where:

$E_b = K_n \phi N$ = the counter emf or so called "speed voltage" generated in the armature

The following expression for speed is simply another form of equation 2a.

Speed:

$$N = \frac{E_a - IR}{K_n \phi} \quad \ldots\ldots (3)$$

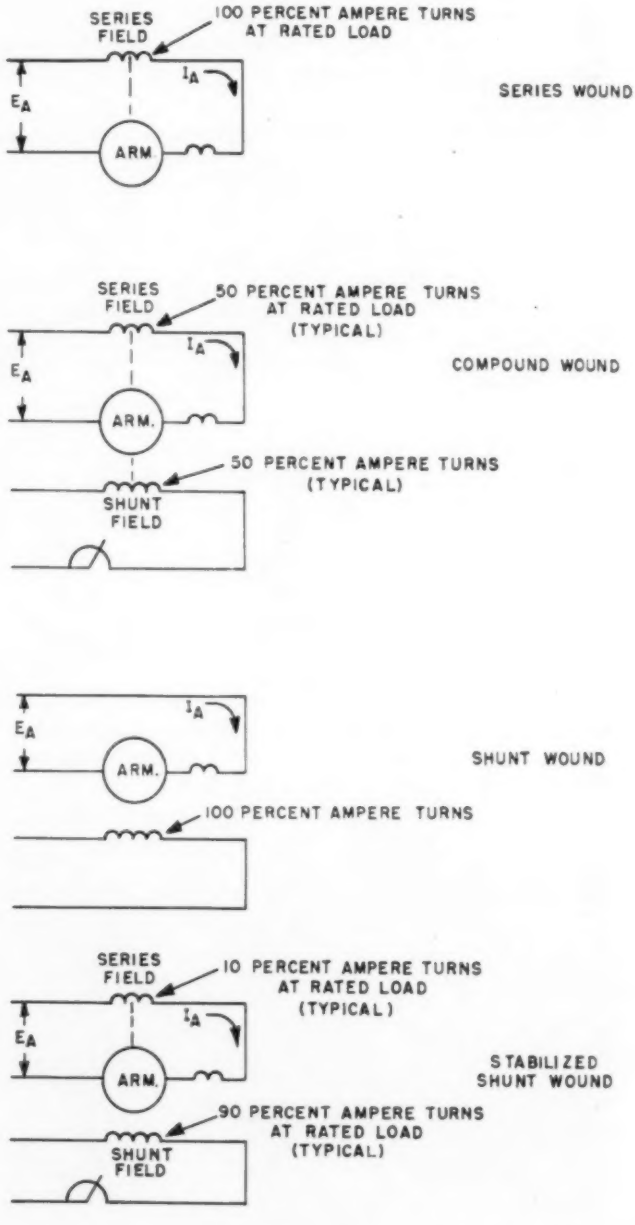
If it were not for saturation of the iron the flux would be exactly proportional to the net field ampere turns and the exact determination of characteristics would be very easy once certain design constants are established. By taking into account, however, the fact that net motor field flux varies with field ampere turns about as shown in Figure 12 the determination of motor behavior is usually quite simple.

Referring to Figure 12, the difference between no load and rated load flux is due to the demagnetizing effect of the current flowing in the armature. This is why speeds of some shunt motors may rise with increased load. By equation 3, we see that a reduction in flux will definitely speed up the motor unless the dropping effect of the IR drop term plus possibly a sag in the terminal voltage are sufficient to prevent it. In order to overcome some of the demagnetizing effect of the armature current a small winding is generally added — thus making a stabilized shunt-wound motor. On large motors, pole face "compensating" windings are used to accomplish this same purpose more effectively.

Formulas 1 through 3 explain at a glance how:

1. Torque is proportional to flux and current.
2. Speed is roughly proportional to armature voltage and inversely proportional to field strength.
3. Weakening the field of a shunt wound motor will speed it up but reduce the available torque — thus giving the motor a so-called "constant horsepower" characteristic.
4. On constant torque variable speed drives it is better to control speed by voltage than by motor field — if other factors permit.
5. The speed of a series motor varies widely with

Figure 11 — Schematic d-c motor circuits.



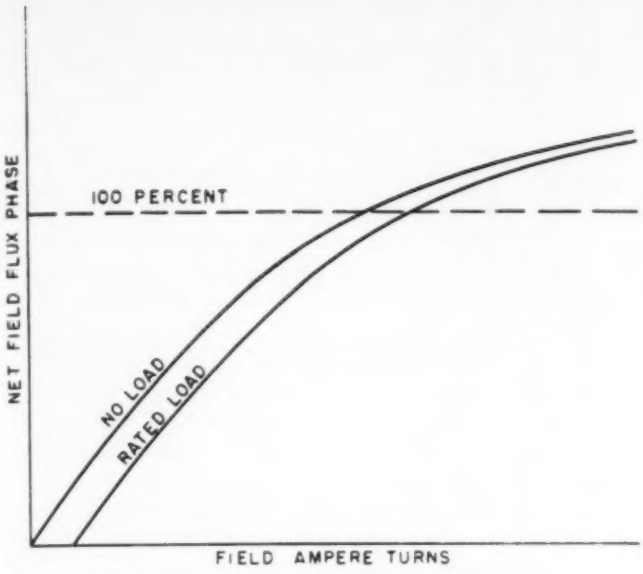
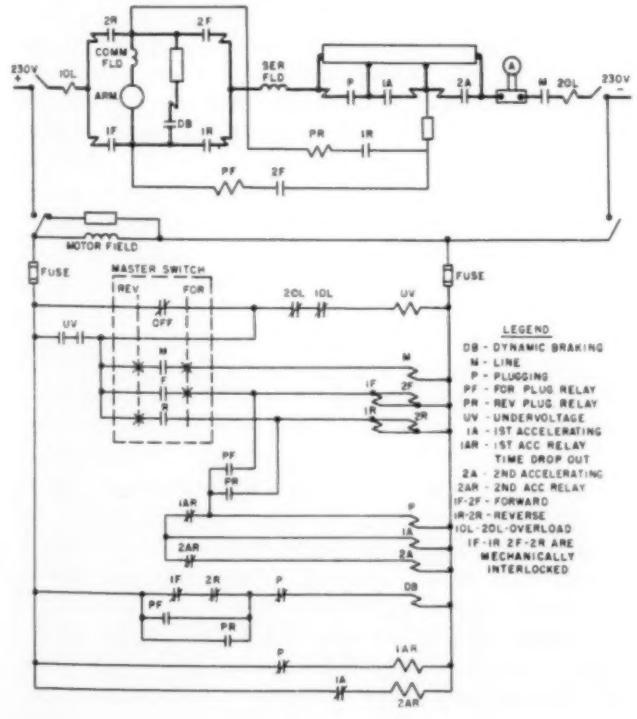


Figure 12 — D-c motor saturation curve.

load, and that it will run away if there is no restraining load.

6. The compound wound motor is a cross between the series and the shunt wound motor, therefore, it will have considerable speed regulation (speed rising 50 per cent from full load to no load on typical motor) but will not run away.
7. In order to start or to reverse a motor on a fixed voltage system, it is necessary to insert temporarily adequate blocks of resistance in the armature circuit to limit the current.
8. During starting, stopping or reversing of a motor by gradual raising, lowering or reversing of the armature voltage, there is no need for the above mentioned armature circuit resistors and their associated large contactors.

Figure 13 — Schematic diagram of a "reversing-plugging-dynamic braking" constant potential control.



CONTROL — CONSTANT POTENTIAL AND ADJUSTABLE VOLTAGE

It is convenient to classify many drives simply by the type of control used, namely: constant potential or adjustable voltage.

Constant potential drives are those taking power from a fixed voltage shop bus, usually between 230 and 250 volts. Armature circuit resistors are required during acceleration, deceleration and reversals in order to limit the currents to safe and reasonable values. Constant potential control is often called "magnetic" control because of the large accelerating magnetic contractors in the armature circuits. It is equally applicable to series, compound, shunt or stabilized shunt-wound motors.

Adjustable voltage drives are those with motor power supplied from an adjustable voltage source, the voltage of which is varied or adjusted to provide

Figure 14 — Schematic diagram of an adjustable voltage reversing control. This type control provides field forcing, rapid acceleration, deceleration and stopping — all under current limit protection. Convenient small adjusting rheostats are provided for adjusting rates of acceleration, deceleration, operating speeds; and for current limits to match safe commutating abilities of the machines. All control devices, responsive to the master control switch, can be small relays since they are in low-current circuits.

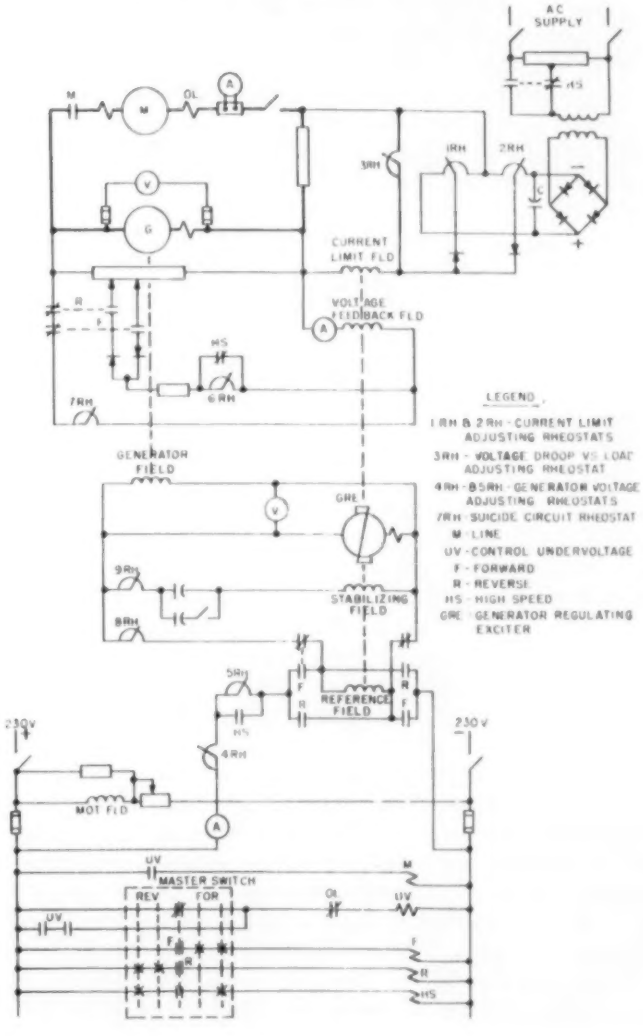


TABLE II

Basic Types of Constant Potential Control Recognized in the Steel Industry

Control type	Nomenclature	Operation
Non-reversing—general mill applications	NR	One direction of rotation only; braking by load friction.
Non-reversing, dynamic braking—general mill applications	NRDB	One direction of rotation only, dynamic braking in the "OFF" position of the control switch.
Reversing, plugging—general mill applications	RP	Both directions of rotation, plugging by reversing the control switch.
Reversing, dynamic braking—general mill applications	RDB	Both directions of rotation, dynamic braking in the "OFF" or "REVERSE" positions of the control switch.
Reversing, plugging, dynamic braking—general mill applications	RPDB	Both directions of rotation, plugging by reversing the control switch, dynamic braking in the "OFF" position.

TABLE III

Horsepower and Ampere Ratings of Constant Potential Steel Mill Control Panels

Maximum hp continuous	Hp rating mill +	Contactor ampere rating		No. of accelerating contactors
		Continuous	Mill +	
25	35	100	133	2
40	55	150	200	2
75	110	300	400	2
*150	225	600	800	2
**150	225	600	800	3
225	330	900	1200	3
*350	550	1350	1800	3
**350	550	1350	1800	4

*For controlling series and compound wound motors with 10 per cent and more series field.

**For controlling shunt and compound wound motors with less than 10 per cent series field.

+Mill ratings are used on intermittent duty drives with totally enclosed non-ventilated 1-hour rated motors.

acceleration, deceleration and speed control. It has no practical use with series motors; it might find some limited use with compound wound motors; but, it is ideally suited for shunt wound motors particularly where speed control or regulation is required on constant torque loads and where rapid and smooth speed changes are essential.

Figure 13 is a schematic diagram of a constant potential control with reversing — plugging — dynamic braking features. Figure 14 is the functional equivalent except that it is adjustable voltage with a rotating type generator voltage regulating exciter featuring current limit during acceleration, deceleration and while running. On such a drive, dynamic braking is seldom necessary (depending upon the application) because the suicide circuit when stopping will drive the generator voltage to zero and thus bring the motor to standstill by regenerative braking.

There are a number of advantages and limitations of adjustable voltage drives as compared with constant potential drives. These have been discussed and presented in print time and again. Nevertheless it seems appropriate at this time to review some of these advantages and limitations before considering specific applications to hot strip mill auxiliary drives.

From the standpoint of performance and flexibility, adjustable voltage is generally superior to constant potential control. It is always possible to use adjustable voltage where a d-c motor is applicable. It is not always possible to use constant potential because there are many cases in which the desired performance simply cannot be realized by this method.

Constant potential control usually costs less. This is true particularly for single motor drives of the ordinary start-stop variety where accurate speed control is of secondary importance. This cost differential arises chiefly from the fact that on adjustable voltage an individual generator on motor-generator set with a-c starter may be required for each such single motor drive; and, on constant potential taking power from the shop distribution system, it is always possible to capitalize on load diversity. To use adjustable voltage on all table side guide adjustment motors of a continuous hot strip mill would for this reason be a waste of money.

One of the major factors affecting the selection of the type of control for a given application is the number of motors which must be simultaneously controlled over a certain range of speed. This plus the ease and flexibility with which adjustable voltage control can be applied explains why, for so many drives, it has become the accepted standard.

Obviously, the greater the number of motors, the more difficult is the control problem and the greater the advantage of using the adjustable voltage system. It is a relatively simple matter to control the field of one generator and thereby the speeds of several motors, but the problem becomes much more complex in the case of constant potential control which requires master rheostat control of all motor fields simultaneously. Such a master rheostat would require an individual section for each motor and it would be very difficult if not impractical to match the various motor speeds point by point. Consider for a moment, d-c runout table motors. Adjustable voltage is the only way.

Constant potential control is regarded as the general purpose d-c motor control in the steel industry. For many years, control panels have been standardized into certain basic types as listed in Table II. Horsepower and current ratings of the panels are shown in Table III.

All major electrical equipment manufacturers offer a complete line of brakes. In fact, the Association of Iron and Steel Engineers have established standard mounting and other limiting dimensions for these magnetically controlled friction brakes. "Off the shelf" brake wheels will fit the type AISE mill motor shaft extensions. Motor-mounted brakes are standard handbook items, although most brakes are not mounted on

the motor. They are usually mounted on the floor or mill housing at the motor. Recent brake designs are characterized by short pickup and dropout times, ease of adjustment, a minimum of moving parts, long-lift brake shoe linings, etc.

Brakes should always be applied for a minimum of stopping duty, and a maximum of holding duty. Electric braking, either by plugging, dynamic braking, or regenerative braking on adjustable voltage is always used to bring the motor to, or very near to, standstill. The magnetic brake is then set to bring it to an absolute stop and hold it there. This insures long life and prevents overheating of the brake linings.

Dynamic braking is obtained by dropping out the line contactors, disconnecting the line voltage and closing a dynamic braking contactor which connects a suitable braking resistor across the motor armature. Thus the motor becomes a generator pumping its stored energy of rotation into the resistor.

Plugging of a motor means that "Forward" contactors are opened and "Reverse" contactors closed. Both the starting and the plugging resistors are inserted into the circuit at the instant of plugging to limit the current. As the motor slows down and accelerates in the reverse direction, the plugging resistor and the starting resistors are removed in sequence by plugging relays which look at the current, and by timed accelerating relays. The portion of this operation which brings the motor to a stop, just prior to the actual reversal of the motor, is known as braking by plugging.

Regenerative braking is used with adjustable voltage control. By reducing the generator voltage to zero, or even slightly beyond zero, the motor current will reverse (as it does for all braking) and pump power back into the generator and into the a-c line. Inasmuch as no armature circuit resistors are inserted, the losses are kept to a minimum by comparison with plugging or dynamic braking, and much of the stored energy of rotation in the drive is actually recovered every time during braking.

Braking losses are highest when plugging because power is actually taken from the line. No power is taken from the line during dynamic braking, the stored energy of rotation simply being dissipated in the dynamic braking resistor. Power is returned to the line during regenerative braking.

So much for the discussion on braking. The accelerating losses with adjustable voltage are also less than with constant potential control since no armature circuit accelerating resistors are used. Thus it is obvious that power requirements of adjustable voltage accelerating and decelerating duty drives can be substantially lower than when constant-potential-controlled.

Adjustable voltage controlled drives in hot strip mills today are built with rotating type regulators. Voltage regulation and current-limit protection are standard features.

Substantial savings in dollars per horsepower can sometimes be realized with adjustable voltage control by designing the drive for operation of the motors at higher than nameplate rated volts — usually 460, sometimes even 600 volts. This is possible with standard shunt or stabilized shunt wound type mill motors, which essentially maintain their torque capacity at these higher voltages and corresponding higher speeds. Front

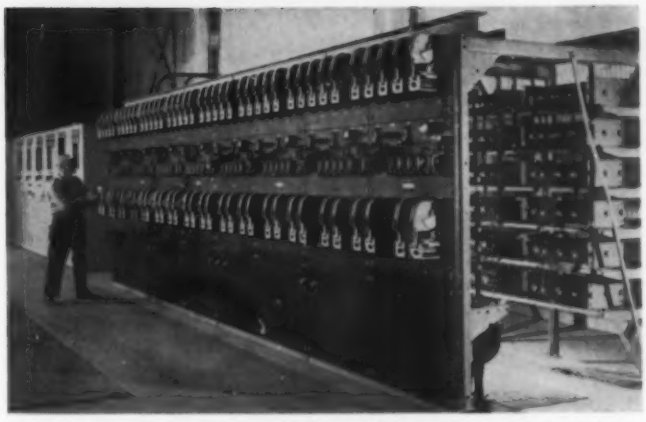


Figure 15 — Typical constant potential control panel line-up, with open self-supporting construction, shows how armature circuit resistors are mounted in racks inside rear structure.

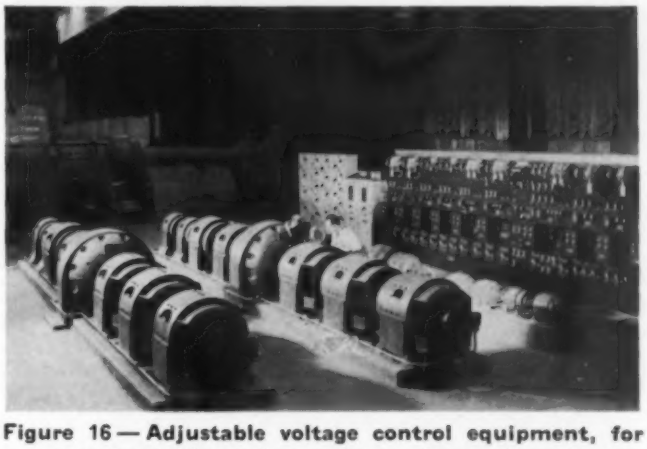


Figure 16 — Adjustable voltage control equipment, for reversing tables and screwdowns of a semi-continuous hot strip mill reversing rougher. Shown are: motor-generator rotating regulator exciter sets and the control panels. The ten control boxes on the panels have hinged doors and mount the regulating circuit instruments and small adjusting rheostats. At the immediate left of panels are the synchronous motor field application units and group assembled 440-volt, a-c control center.

and back tables of a semi-continuous hot strip mill reversing rougher are examples where the use of 460 volt generators to supply the motors is standard practice. The available horsepower from these motors is twice that on the nameplates.

An outstanding example of a single or twin motor auxiliary drive which must be adjustable voltage controlled is the flying shear. Not only must the shear be closely speed-regulated to that of the mill, when cutting to length, but it must also start and stop quickly to avoid making false cuts when cropping front and tail ends of the strip. There is considerable inertia in the shear and the motor itself. Therefore, it is necessary to operate the motor with full field at all times to obtain the most torque per ampere of armature current. There are several reasons why it is impractical to control shear speed over the entire range by motor field, the main one being that the weakening of the field in order to increase speed will reduce the available motor torque by at least a corresponding amount. Such a characteristic cannot be tolerated in a flying shear drive because the available motor torque is the lowest just when the demands are greatest. This example illustrates well the

established fact that wherever rapid changes in speed are required and where accurate speed control is important, it must be accomplished by controlling armature voltage.

Maintenance expenses tend to be lower on adjustable voltage drives. This is true both mechanically and electrically. It is true mechanically because this control inherently provides smooth stepless acceleration and deceleration. Torques build up smoothly yet quickly and are sustained throughout the accelerating period at a relatively constant value by comparison with those of constant potential control. On the other hand, with constant potential, the torque builds up abruptly and varies in a series of sharp peaks and valleys as the accelerating contactors sequence through their operations. Lower electrical maintenance on adjustable voltage control results primarily because the control devices are smaller and carry lower currents than those on constant potential panels with their large and expensive armature circuit contactors which must handle current peaks of two to three times normal.

So — after reviewing the pros and cons, one must conclude that adjustable voltage control is definitely superior from the standpoints of performance, reliability, and flexibility. Cost will, however, favor constant potential control on many drives. The absence of individual motor-generator sets also gives a space advantage to constant potential. Cost and space considerations are responsible for thousands of feet of constant potential control panels recently installed in the industry. Inevitably, there will be borderline cases in which it is difficult to decide what type of control should be used. Here every effort is usually made to view the drives in their true perspective. How important are they in their relation to the mill as a whole? Much thought is given to performance and reliability. Can a drive failure seriously cripple the mill? If so, the extra dollars for adjustable voltage are often considered as money well spent. Such has been the trend in engineering thinking; and, one can hardly dispute its soundness.

D-C CONSTANT POTENTIAL POWER SUPPLIES

The choice here is between motor-generator sets or mercury arc rectifiers.

Synchronous motor-generator sets are very well suited for this type of service. They inherently possess the following features:

1. D-c voltage is independent of voltage fluctuations in the a-c system.
2. They adapt themselves readily to regulator control, providing constant voltage even with wide fluctuations in d-c load and in power supply frequency.
3. They parallel easily with other equipments.
4. They absorb regenerative loads automatically.
5. The synchronous motor will supply leading kva improving the system power factor.

Many of our new steel mills use mercury arc rectifiers for shop power. There are, by comparison with the motor-generator sets, certain advantages such as:

1. Higher efficiency. The efficiency of a rectifier is substantially higher than that of a motor-generator set at full load; and, it is very much higher at light loads.

Figure 17 — This 1500-kw, 250-volt, d-c metal-enclosed, pumpless mercury arc rectifier equipment has from left to right: transformer, rectifier cubicle, d-c metering section, master d-c control unit and seven d-c feeder breaker compartments. Above each feeder compartment are mounted the load current measuring resistors associated with the automatic breaker reclosing features. The pumpback resistor is the large one at the left.

2. Installation cost of a pumpless rectifier package substation equipment is lower than that of a motor-generator set.
3. There are no moving parts.
4. They can be operated in parallel with other d-c equipment.
5. They do not contribute to short circuits on the a-c system.

Rectifiers *cannot* handle regenerative power. This, however, is not a practical limitation since suitable pumpback resistors are provided to absorb the relatively small amounts of net regenerative power that may occasionally appear at the rectifier terminals.

Figure 17 shows a recent installation of a pumpless mercury arc rectifier equipment rated 1500 kw, 250 volts d-c. Constant potential power supplies ranging from 1000 to 3000 kw are typical for hot strip mills. There is a very definite trend toward rectifiers.

A-C MOTORS AND CONTROL

As many as 75 small induction motors and 50 a-c controlled solenoid hydraulic and air valves may be used on a hot strip mill. Perhaps 40 motors are required for exciter sets and ventilating fans alone. These are usually of the open dripproof type since they are located in air-filtered motor rooms. The others are located elsewhere and are therefore built in totally enclosed fan cooled construction.

It is now common practice to combine small motor starters, solenoid and miscellaneous low voltage feeder control panels into factory assembled NEMA type I enclosed control centers such as shown in Figure 18. A typical control center is only 20 in. deep, 90 in. high; and, with all devices front-connected it can be located against any wall or tucked between building columns. Starter units may also be installed in both front and rear of sections for back-to-back arrangement without increasing depth.

An incoming line breaker is frequently included with each assembly as a convenient means for manually

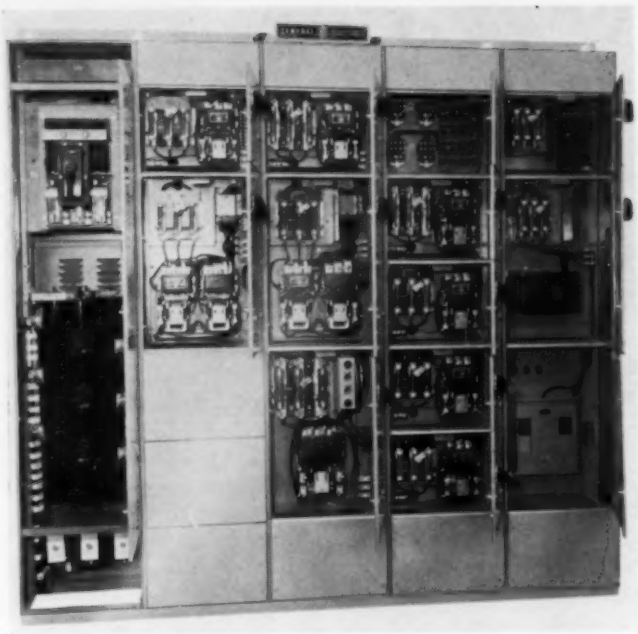


Figure 18 — Typical steel mill, front-connected, low voltage, a-c control center. Top equipment with doors open has incoming current limiting reactor and is arranged for connections at bottom. Equipment with doors closed is arranged for connections at top.

deenergizing the control center power bus, and to provide short circuit protection, up to at least 25,000 amperes. Each starter has its own compartment. All starters are of the combination type, either with high interrupting capacity current limiting fuses and disconnect switch, or with line breakers, plus contactors, thermal or induction type overloads, control power transformer, under voltage protection and one or two extra interlocks for miscellaneous use. Nearly all solenoids are 110-volt, a-c operated; and, standard control panels, with incoming line switch and fuses, 460/115-volt transformer and solenoid control contactors, are normally mounted in these control centers. This also is the logical location for miscellaneous 440 or 110-volt supply feeders for recorders, gages, selsyn systems, etc.

QUALITY CONTROL DEVICES

New tools are now available making possible further improvements in quality control and cost reduction. For years incoming and outgoing strip temperatures have been measured and recorded. If the strip was too hot it was held on the delay table. Today thickness and width can also be measured on the fly as the strip comes out of the mill — soon enough usually to do something about it if gage and width are not within tolerance limits.

X-RAY GAGE

Errors in strip thickness can be costly — particularly if gaging is done after coiling by which time a large amount of off-gage material has been rolled before being detected. The X-ray gage was originally developed for hot strip mills. Its reputation to date is excellent; and, it is now considered as one of the most essential items of equipment on a hot strip mill.

There is no other known way to gage hot strip as accurately and as quickly as by X-ray gage. In the first place, it is a non-contacting gage; that is, there is no physical contact with the strip. It is therefore not affected by vibration and speed of strip. Since it operates on the principle that X-ray absorption is proportional to the product of density times thickness, it is practically independent of strip temperature. Outstandingly sturdy construction of the detector units and enclosing tanks has enabled these gages to operate under the worst conditions of heat, moisture, dirt and mechanical abuse. Figure 19 shows the components of a complete equipment. Figure 20 shows how one user has mounted the top detector head to protect against damage by cobbles.

The latest design 100-kv gage can handle mild steel 0.040 in. to 0.400 in. thick. It is equally suitable, incidentally, for other metals such as aluminum and copper, and all special steels such as stainless, silicon, duraluminum, etc. A 50-kv gage is also available, but is too small for a steel hot strip mill.

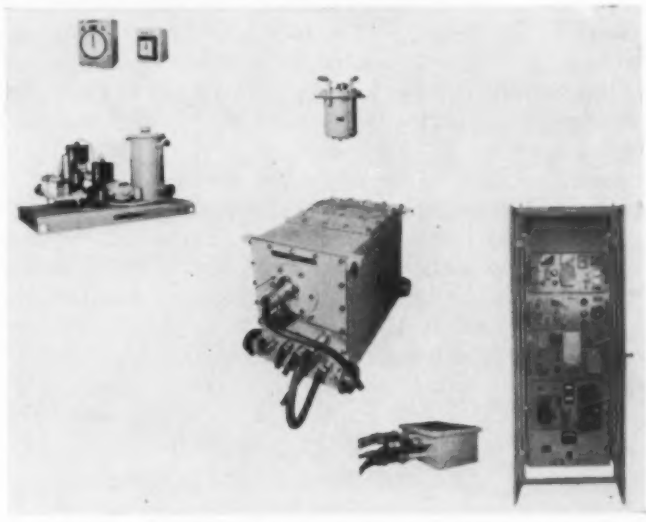


Figure 19 — Components of X-ray gage are top detector mounted above strip, gage tank directly below strip and on track for ready inspection, junction box at end of track, oil flow panel and control panel in motor room. Gage indicator, deviation indicator and operator's control devices such as On-Off switch, gage indicator positioning switch, zero adjustment switch and test push button are all mounted on cabinet located on last mill stand housing. Not shown is recorder.

Figure 20 — X-ray gage top detector mounting was designed to protect it against cobble damage.

WIDTH GAGE

The width gage is a high accuracy non-contacting device for measuring width of moving hot strip. The first model of the present design gage was demonstrated at the AISE Convention and Exposition in Cleveland during September 1950. The first gage was installed early in 1952 at the Irvin Works of the U. S. Steel Corp. At the present time at least six gages have been built as the industry is coming to recognize the importance of accurately measuring and recording strip width as it is being rolled.

Figure 21 is a composite view of such a gage. The usual location for the detector head is 15 ft above the strip after the last stand of the finishing train. One user is designing a portable mounting to permit gaging after the reversing rougher as well as after the finishing mill.

The width gage offers a possibility of high return on initial investment. Consider for example, a mill rolling 100,000 tons of steel per month with an average width of 36 in. If the operators are able to hold width $\frac{1}{8}$ in. closer to the desired value, approximately 350 tons per month, will become salable strip rather than scrap. If scrap is valued at $30 per ton, and strip at $80 per ton, the increase in value of $50 per ton represents $17,500 per month or $210,000 per year. Even if half this amount is used as an estimated saving the potential return will be readily apparent.

The theory of operation follows. The detector head, mounted above the strip, has two scanners. By means of a motorized precision lead screw, the scanners are located nominal strip width apart. Each unit has one edge of hot strip imaged on it by a lens. The necessary illumination is furnished by the strip itself. Edge temperatures as low as 1350 F are adequate. The optical images are converted into electric charge patterns by phototubes. A rotating slotted disc provides the means for repeatedly sweeping across the edge of the strip at right angles to the direction of strip travel. Pulsating square wave d-c patterns result at each edge of the strip. The time axes of these waves are added together and compared with a reference to produce a current proportional to width deviation.

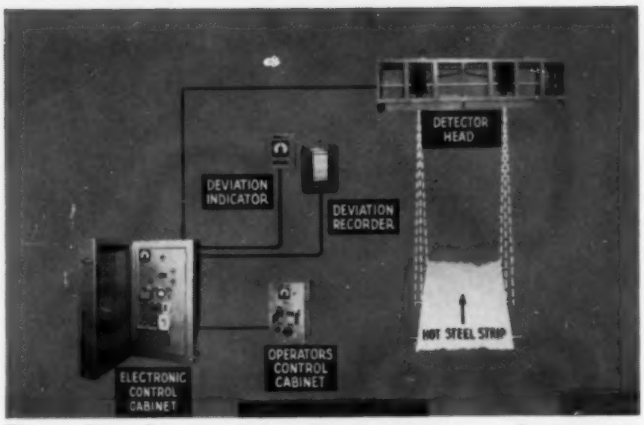


Figure 21 — Component parts of width gage. Accurate to $\frac{1}{8}$ in., the gage responds within a fraction of a second to variations in width of strip, making possible substantial reductions in edge scrap.

Sidewise motion of the strip has little effect on accuracy if restricted to plus or minus 3 in. from nominal center. This is because sidewise strip motion simply means that the pulse from one scanner will be longer while the other is correspondingly shorter, and their sum is unchanged.

Standard gages have a width range from 10 to 98 in. They are designed to operate from any standard low voltage a-c power supply.

There is every indication that most high production hot strip mills will have width gages before long.

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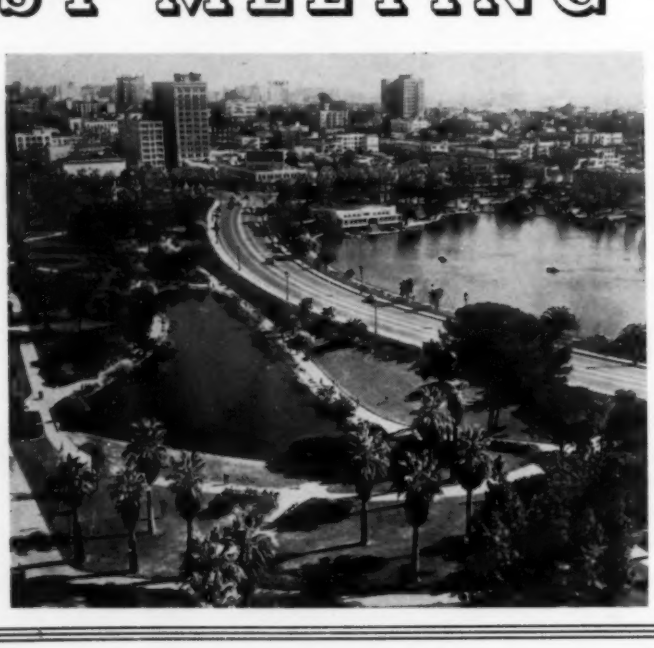

Scope of the Furnace Fume Control Problem

By H. L. RICHARDSON
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. . . . unfortunately, gas cleaning efficiency is not necessarily related to gas appearance . . . this should be taken into account when selecting cleaning equipment . . . .

▲ THE history of all metallurgy is one of continuous improvement and development, and the field of ferrous pyro-metallurgy has good reason to be proud of its achievements. Each of these progressive steps, whether it related to improved techniques, better product, accelerated production, or reduced costs has required parallel developments in allied industries. The requirements for these developments in the art of gas cleaning have been major. The magnitude of the problems in this phase of the refinement of iron is rarely appreciated by those not closely related to the application of this art.

Less than ten per cent of the tonnage of total material produced in a steel mill is the saleable product. Over 90 per cent of the weight of this tonnage in the conventional mill is by-product and waste gases. The blast furnace plus the open hearth will produce ten to twelve tons of gaseous product for every ton of ingot. Even the coke oven will be required to produce well in excess of 300 lb of gas for this same ton, the exact amount depending on the details of operation. The slabbing and the blooming mill are rarely considered as contributors to the total tonnage of gaseous production. In addition, for every kwhr used anywhere in the mill, twelve to twenty lb of boiler stack gases must be discharged.

Historically, gas cleaning was first applied to recover materials of value. The second requirement was the cleaning of by-product gases to enhance their economic value. The third and final phase is the one which now holds the greatest interest—the reduction of air pollution. Under the first category, it is rare today to find materials of value which can be profitably recovered where this is not being done. Under the second category, the technology has kept abreast of the demand. In some instances, the blast furnace and coke oven gases are cleaner than the air which is used for their combustion. These two by-product gases are the ones with major commercial value, and there is no known existing or potential demand for fine cleaning which cannot be met with present technical knowledge.

In this discussion, we are principally interested in the problems which can be classed as being solely related to air pollution control. Oddly enough, the first commercial application of electrical precipitators was for elimination of an airborne nuisance. The major processes for the treatment of iron after it leaves the blast furnace generate gases which have no economic value. The materials carried in suspension in these gases do not have sufficient value to warrant their recovery. Unfortunately, this is true in the open hearth, the bessemer, the electric furnace, the newer oxygen surface blower, the scarfing machine, the power boiler and most of the others. In all of these, the control of air pollution requires added invested capital and maintenance costs with no return. The higher process heats; more rapid processing; and the increasing use of oxygen has presented the technician with added complexities in cleaning these gases. As these are overcome and new knowledge is gained, this new knowledge must be utilized. First, we must correct our aims and concept of the goals which we are to achieve. This reevaluation is proper procedure in any instance. Second, there are new horizons to consider. Within the memory of all of us, there was a time when industry was almost completely self-policing in the matter of air pollution. In fact, at one time air pollution was often welcomed as an indication of a healthy economy. Any control of this was merely the expression of the steel industry to remain a welcome member of the community. This power of policing is rapidly passing from the plant to specific political enforcement agencies. If this trend continues at its present pace, air pollution control will shortly pass into an entirely new phase industrywide, as it has in many local areas. The mill will be told, by ordinance, just what it can and cannot do in relation to stack emission. Today, many areas demand the regulation of the weight of suspensoids which are discharged in a given measure of gas, such as grains per cubic foot or pounds per thousand pounds of gas. In no

observed instance has any such regulation been amended to allow an increase in these amounts. It is well known that the general trend is to decrease the amount of allowable emission, gradually but continuously.

The magnitude of the work and cost involved in developing and applying satisfactory gas cleaning equipment for the solution of most of your problems is great. One cannot aim solely to satisfy an existing ordinance for this year or next. One must try to anticipate the regulations under which one will be operating ten or twenty years from now. Who will establish these advanced criteria? It will be the general public. One must realize that the preponderance of people who observe any source of air pollution are laymen. They do not think in terms of grains or pounds or cubic feet. If the stack discharge can be seen, there is air pollution. Let us recognize it; it is the opinion of the laymen which will force on us the gradually advancing goal of visually clean stacks. This is already accepted in some regulations which carefully define allowable stack emission in technical detail, and then in the fine print casually state that should these requirements be met and a nuisance still exist, it will not be allowed. One specific ordinance, quite often used as a pattern for new legislation, states: "It shall be unlawful for any person to cause, permit, or maintain any such public nuisance notwithstanding the provisions of Paragraph 1 of Section 8 of this chapter." Paragraph 1 of Section 8 is a technical description of allowable emission. (1) *

If one accepts this trend, then one must revise the standards of evaluation now in general use. These are primarily based on the weight of suspensoids carried by a given amount of gas. This is no measure of the visual appearance, or the light-scattering power of a stack emission. The weight of material present and the stack appearance are almost completely unrelated. The basic ASME code allows 0.85 lb of solids per thousand lb of gas. Let this material be spherical and 50 microns in diameter. Reduce this same weight of material to one micron size particles and the exposed surface is increased by fifty times, the number of particles present for light-scattering effect is increased by 125,000 times. These are the principal factors which govern the visual appearance of a stack discharge. This is also what we mean when we freely say the weight of material present has no direct bearing on stack appearance.

The Ringlemann chart was developed for this reason. This gave numerical values to stack appearance with no consideration to the weight of material present. The necessity for the refinement of such a concept has been recognized by many of the research workers in this field. Of particular interest is the work of Hemeon and his associates at Mellon Institute. (2) These gentlemen have developed a method of evaluating quantities of light-scattering solids in such a manner that their opacity can be measured by an instrument. The reproducible results of numerical value are based solely on the light-scattering power of the collected suspensoids with no measure of the unit weight. They have coined the word "cohs" to express these values. At present, this appears to be a very reliable basis of such measurement.

Through the courtesy of Mr. Hemeon we are permitted to reproduce here the visual concept of his basic reasoning. A typical airborne suspensoid was carefully sized and the individual particles counted and weighed. Figure 1 shows this relationship. An idealized model of this material under 15 microns was developed. (Figure 2). This is idealized in that the heterogeneous particle sizes have been reduced to a few standard sizes so that the 100 particles 12 μ or less shown here have the surface area of the original sample. Here is one particle of 50 microns as shown, not at all unusual in field experience. If this one particle is removed, as is easily done with any of the semi-crude mechanical collectors, we have removed over 97 per cent of the material by weight. We have made no visible and no measurable improvement in stack appearance. Even among these smaller particles, the removal of those of greater diameter will not appreciably reduce the light-scattering power of a stack discharge. It has been demonstrated that the removal of 85 per cent of the weight of material suspended in a typical power boiler stack discharge made no measurable reduction in the "coh" value of the stack effluent. (3)

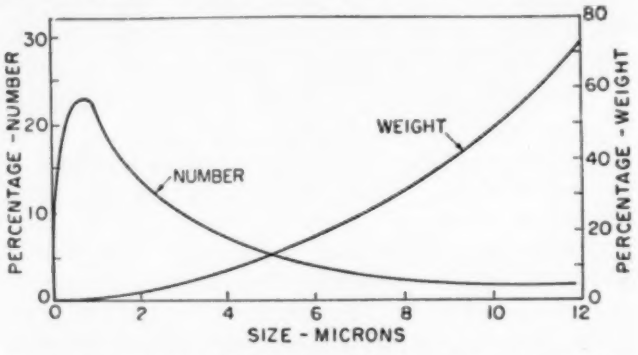


Figure 1 — Weight relation to size and number of particles in a typical airborne suspensoid.

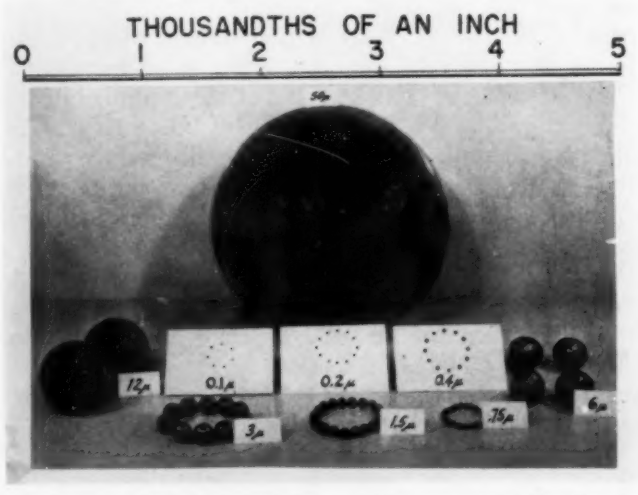


Figure 2 — Visual comparison of the suspensoid in Figure 1 is given by model.

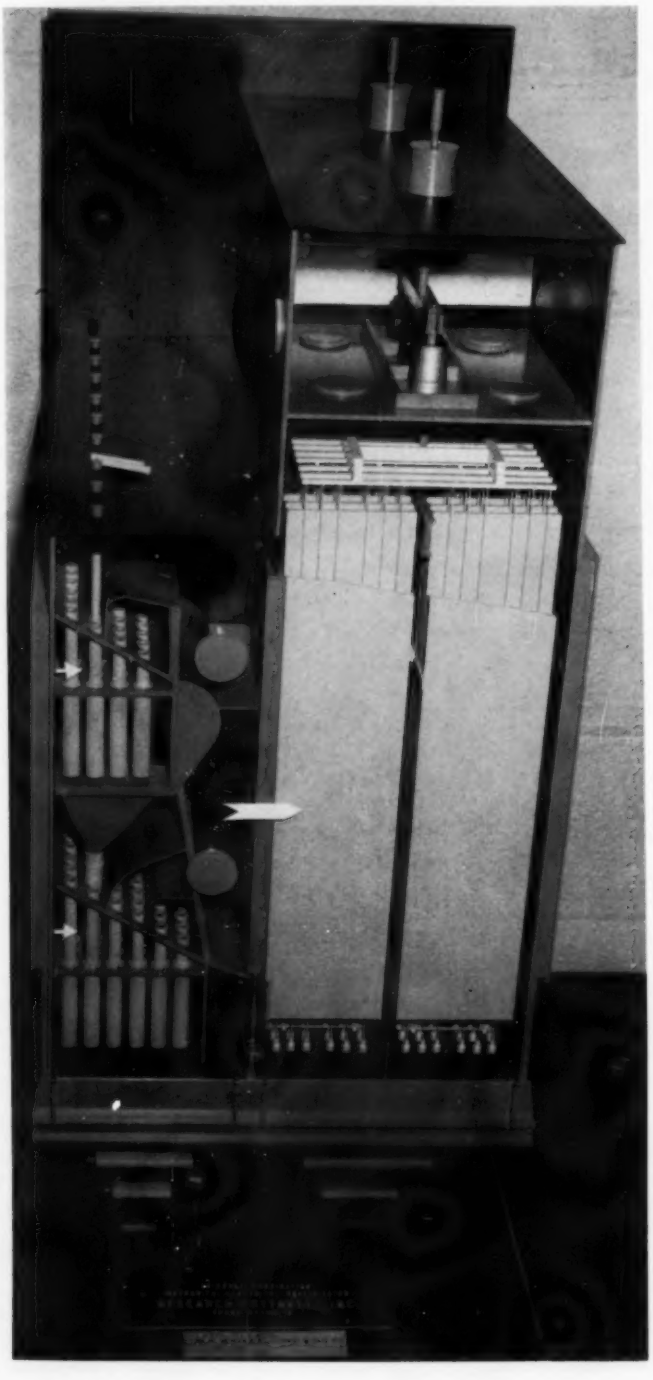
Technically, there is no air pollution control problem in industry which cannot be overcome to any required degree. Unfortunately, one must also consider the economic aspects. This consideration is even more important as we are returning no income to the mill,

*Numbers refer to bibliography at end of this article.

and are adding to the cost of production. Any expenditure for equipment must fully justify its cost. If this is an investment for good will only, it must meet not only specific legal requirements, but the critical opinion of the general public. It becomes evident that one must more and more emphasize the removal of the fine as well as the coarse material.

Basically, there are five different types of gas cleaning equipment available; i.e., settling chambers, filters, scrubbers, inertial collectors, and electrical precipitators. Alone, or in combinations, these five basic types may be adapted to specific applications. As an example, Figure 3 is an integrated mechanical collector and electric precipitator combination. This gives high collection efficiency on both coarse and fine particles with minimum space requirement.

Figure 3 — Integral combination of mechanical collector and electrostatic precipitator gives good efficiency.



In the study of furnace fumes in the steel industry, we are working in a field where the control of stack appearance is almost completely one of the collection of fines. These fines may represent a minor portion of the total weight of solids being discharged to atmosphere, but visually they furnish practically all of the material which causes light scattering. The collection of this type of material is peculiar to the field of electrical precipitation. No suspensoid is too fine for collection in this equipment. A specific problem is encountered with the cleaning of stack gases in each heat refining phase of the production of steel. The magnitude of these problems varies widely. The most serious of these today is the cleaning of the gases from open hearth shops.

This condition was realized by the steel industry long before it gained its present magnitude. The steel industry's early recognition of this is evident in the time and money appropriated over the years for research in the study of a solution. Every applicable device which has been offered has been considered, and where warranted given full pilot plant trial. The gases from the open hearth shops contain a true fume, and consequently the gravity and inertial types of collector are of little value. Direct filtering has not proved commercially practical to date, although competent studies are still under way on this. A wet washer with a high pressure drop has proved technically satisfactory, but to the best of our knowledge has not been installed on a commercial scale. The principal objections have been the severe corrosive properties of the gases when wet; the power consumption in the high pressure drop; and effluent disposal. The electrical precipitator has proved applicable, and has been in operation for cleaning open hearth gases commercially for more than four years. Figure 4 is the flow diagram for such an installation, and Figure 5 shows the first commercial application of electrical precipitators for this work. The operation of the furnace and the cleaning objective must be clearly understood before any work is undertaken. There will be a difference between the hot metal shop and the cold metal shop. In addition, oxygen lancing or enrichment will change the apparent density of the stack discharge.

During the charging and melt-down period, there is a discharge of as little as 0.05 gr per cu ft, and this cannot be visually detected. A 0.05 gr per cu ft stack discharge during the decarb lancing is visible. Equipment which will give a clean stack during the lime or ore boil will probably, with the same efficiency of removal, present a definitely dirty stack appearance during checker and flue blowing. The amount of material present and the particle size varies continuously from tap to tap. The volume of gases to be treated, as previously stated, will be in excess of five tons per ton of ingot. One study which might be of benefit would be that of reducing the excess air. In general practice today, it is not at all unusual to have more than 100 per cent excess. The design of the fantail and checkers makes it practically impossible to reduce this to the range which would be good power boiler practice. Any reduction at this point, however, would reduce the overall cost of the gas cleaning plant.

Careful studies have been made of the remainder of steel's major gas cleaning problems and most of the

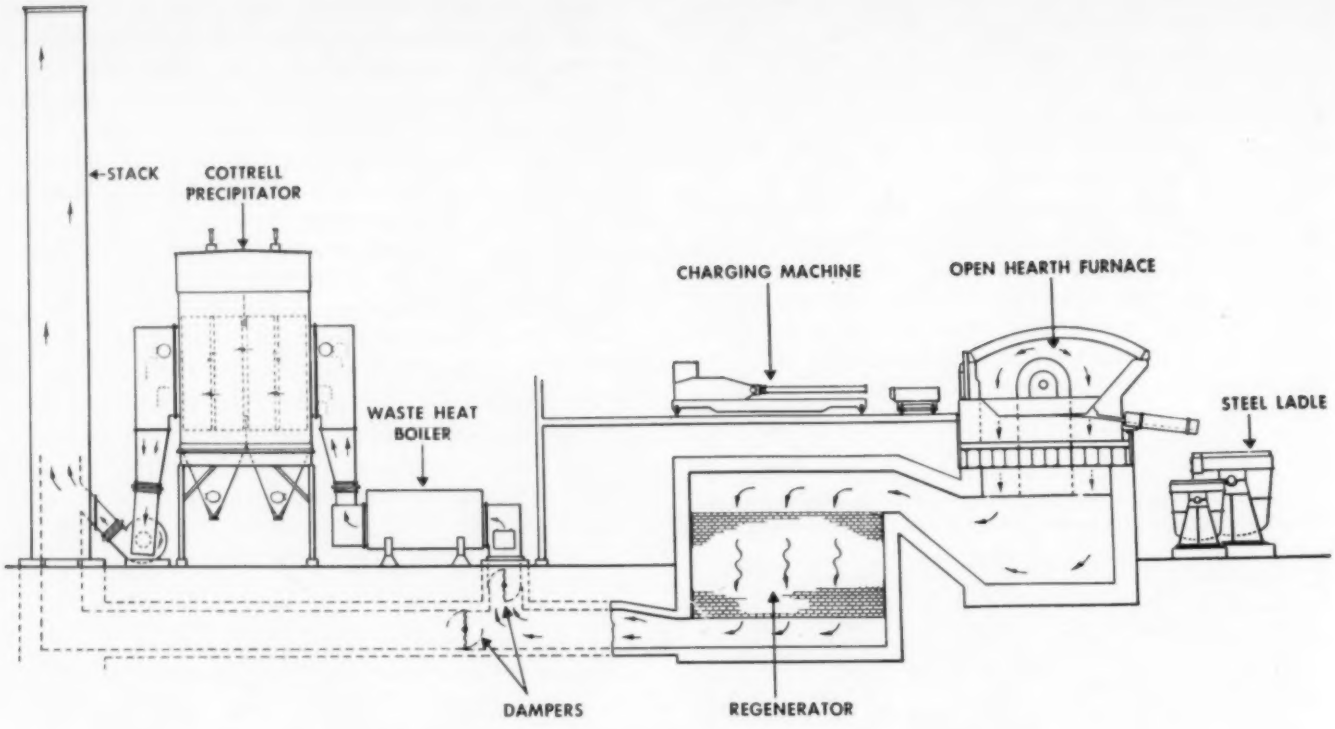
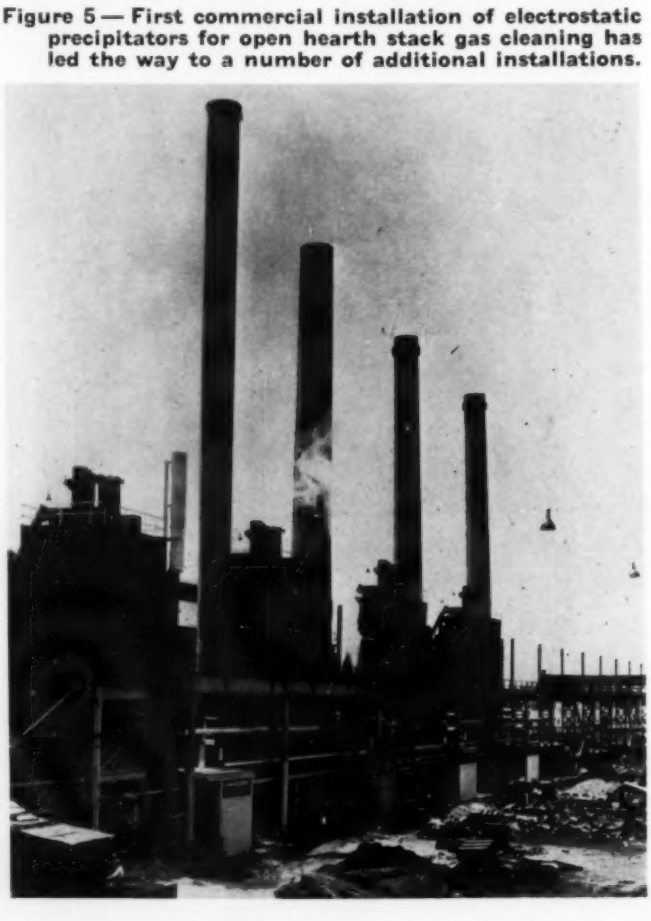


Figure 4 — Flow diagram for open hearth gas cleaning installation.

minor ones. Some of these do not lend themselves to economic solution. In this relation, the conventional bessemer converter is a prime example. These fumes offer no technical difficulty in removal from a gas stream. We must admit, however, that we are faced with one of a serious mechanical nature. This is the collection of the gases to allow them to be treated. The present method of operation of this vessel requires that a long flame be visible for process control. This operation also requires that the vessel be in three different positions. To satisfy these requirements and still to withdraw the gases into a hood by negative pressure requires the inclusion of tremendous amounts of false air. To date, the best design would require that a 30-ton vessel be equipped with gas cleaning capacity of well over 300,000 cfm. Economics are against the cleaning of such an amount of false air. There has been an enormous amount of expert study on this, but to date no practical answer has been found. To eliminate air pollution from this source we must approach this from one of two methods, either design a hood which will meet all of the operational requirements and still produce a reasonable gas volume to be treated, or revise the operation in such a manner that a conventional hood can be applied close to the lip of the vessel.

In the electric furnace shop we are again faced with a difficult task in collecting the gases for treatment. The problem parallels that of the bessemer. In the production of single slag heats the answer has been found in the direct removal of the gases from the interior of the furnace by vacuum. This cannot be done in the production of stainless or any double slag heat. For this reason, the tapping of the top of the furnace was abandoned by the company which first tried it in this country. At present, the best that can be done is to enclose the entire electrode assembly with a hood, and this has been done where cleaning was imperative. Hooding in this manner, however, creates its own complications. The operator has a very strong and valid objection. Enclosing the electrode assembly so that it is not under visual observation entails an operational hazard. An added objection is the increased labor necessary in re-

Figure 5 — First commercial installation of electrostatic precipitators for open hearth stack gas cleaning has led the way to a number of additional installations.



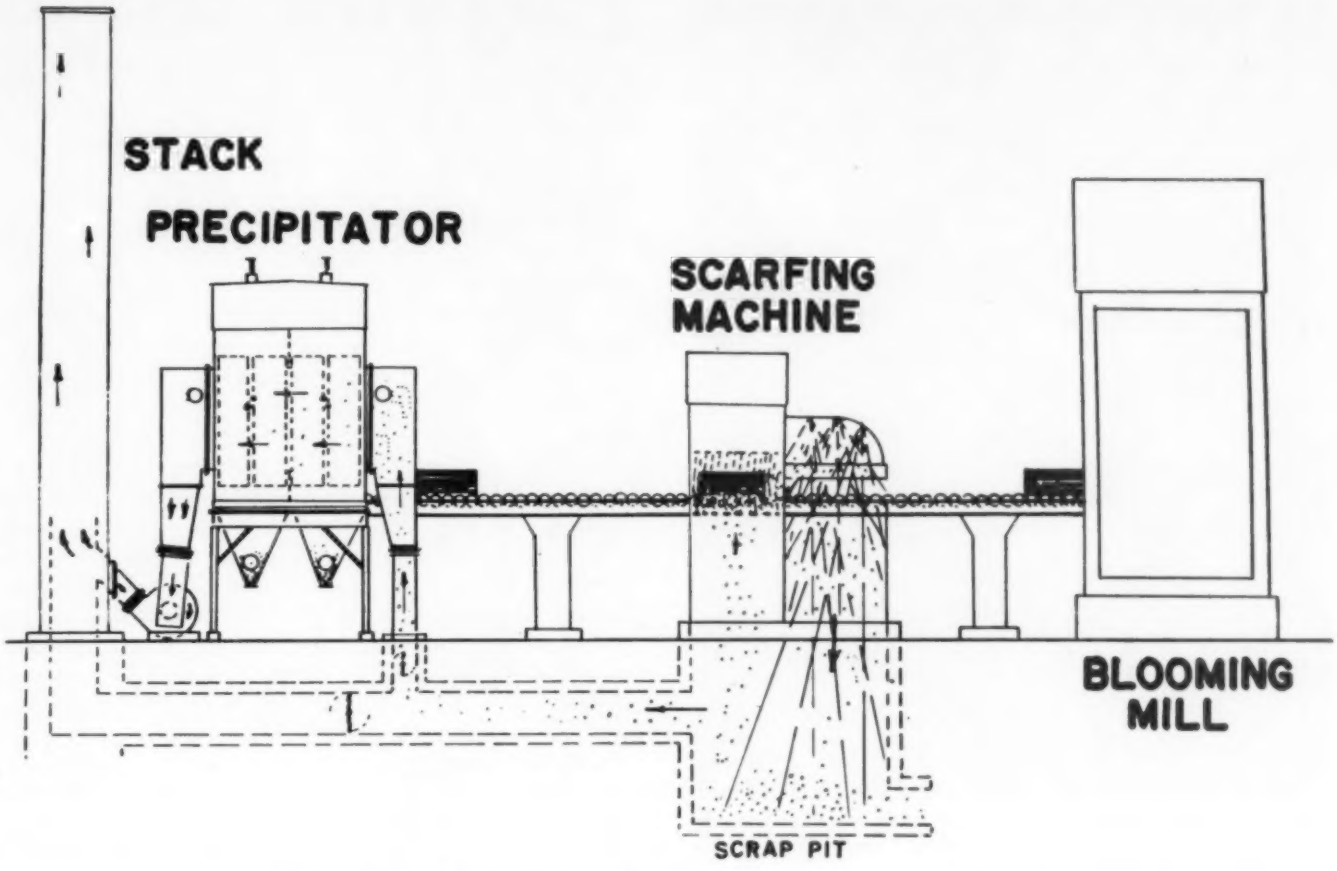


Figure 6 — Flow diagram for scarfing machine gas cleaning installation.

placing a roof. The hood must be removed before the roof is available, and must be replaced over the new roof. This hood cannot be a very light structure, as there are periods of intense heat when warpage takes place. The increasing trend to larger furnace diameters for higher tonnages only complicates this. At least one shop with this type of hood still must not use it after the first slag due to placing the top under a slight negative pressure. Regardless of the volume to be cleaned, 0.6 to 1.0 per cent of the charge weight will be discharged as fume suspended in these gases.

The newer process from Austria, which has as yet no accepted standard appellation but which is variously called the Linz-Donawitz process, the oxygen converter or the oxygen impingement process, presents a much more encouraging picture. This is too new in this country to attempt to predict its possible influence on American practice, although first reports are very favorable. In some manner, the report was made that these gases could not be cleaned. The report is absolutely untrue. Pilot plant studies have been made in this country and the gas cleaning industry is ready to clean these gases to any reasonable degree. From the work in Austria it appears there will be a fume emission from a 30-ton vessel ranging from 35 to 60 lb per minute during the blow. For any given degree of cleanliness required, the size of the gas cleaning equipment will be governed by the volume of gases to be treated. There are divergent opinions on the design of the hood at the top of the vessel which will cause this volume to vary over wide ranges. If one design now recommended by its sponsors is accepted, the hood will fit tightly over the top of the lip, and there will be no false air. This will, of course, be the minimum volume. Under this design the gases will be cooled and cleaned for use as a fuel with a net Btu value of something on the order of 290. Another design incorporates an open space at the lip of the vessel to allow false air to be drawn in at this point for combustion of the CO. The amount of air to be drawn at this point has not been completely cleared. The true gases will have a temperature in excess of 3000 F. If three parts of air to one part of gas is indrawn, the final products of combustion will have a temperature of about 2400 F. In either instance, the gas must be cooled for cleaning. This cooling will be governed by the type of cleaner to be used. If this is to be an electrical precipitator, as has been proved applicable, the temperature must be 500 F or less. The practical method of cooling here would be direct vaporization of water into the gases.

Collection of fume from the scarfing machine is a unique problem. Although this fume is suspended in the gas which is saturated, and quite often carries water of entrainment, with proper design of collecting equipment dry recovery can be achieved. Measurement of the exact amount of fume present at any given instant is difficult due to the very short duration of a fuming period. This value has been accepted in some cases at approximately 0.8 gr per cu ft of fine fume. The light-scattering power of this material is very high in relation to the weight present. The volume of gases to be cleaned normally vary from the range of 20,000 cfm for the lightest two-edge table to something on the order of 150,000 cfm for the heaviest four-side ma-

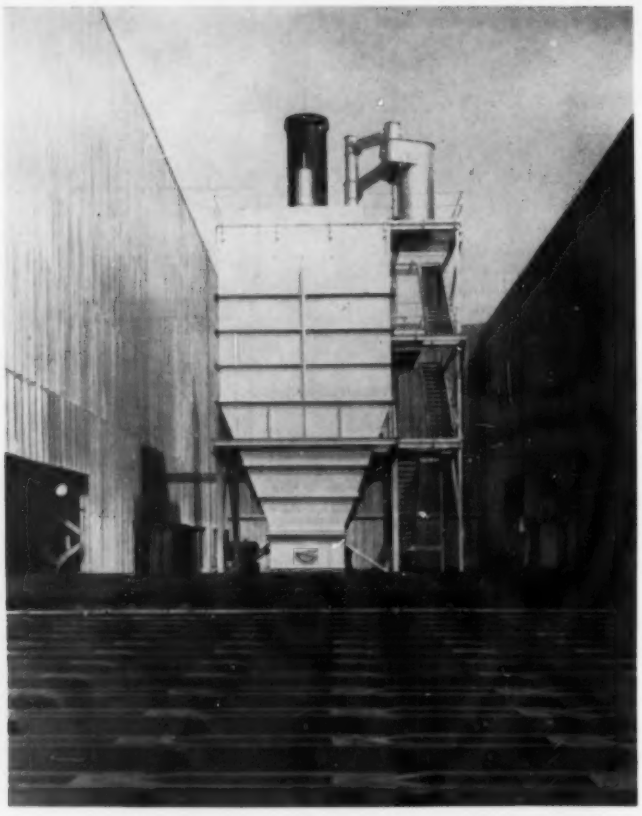


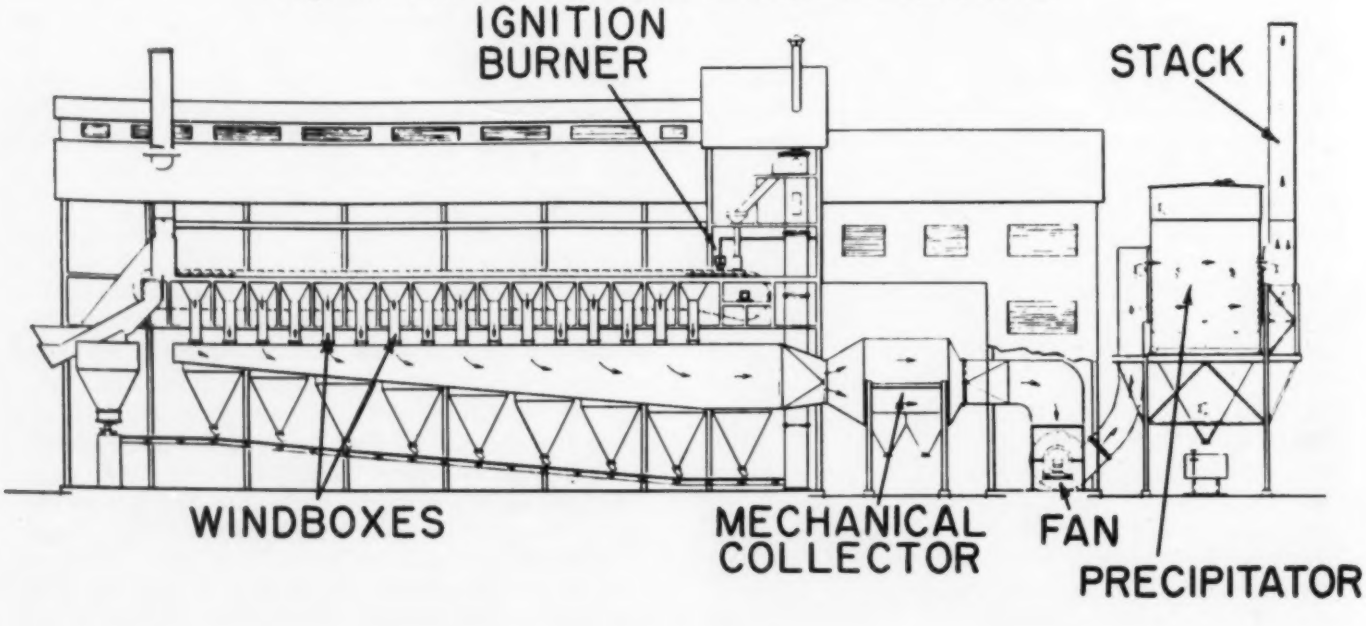
Figure 7 — First commercial installation of electrostatic precipitator for cleaning scarfing machine gases is located at an eastern plant.

chines. Commercial application of cleaners to this has been very effective. Figure 6 is the flow diagram for this cleaning, and Figure 7 shows the first commercial application of electrical precipitation to this problem.

The solids in suspension in the discharge gases from an iron ore sintering machine require two separate steps in their removal. There is a mechanical carry-over of very coarse material which may constitute as much as 90 per cent of the total solids by weight. This is particulate matter carried mechanically through and from the bed, and the amount will vary with the porosity of the bed, its depth, and the general operation of the machine. There is also present a very fine fume generated in the hot zones of the bed. This portion of the sinter plant stack discharge must be treated as a true fume which will pass through a mechanical collector. Complete cleaning of the gas from a sintering machine obviously entails the use of a mechanical collector of gravity chamber in combination with equipment which can remove the very fine particles. The amount of material present and the volume to be treated vary radically with the size and type of machine, its operation, the source of material, and the physical properties of the material fed onto the bed. Visually clean stacks have been maintained from commercial installations for this problem. Figure 8 is the flow diagram for such an installation and Figure 9 shows the first commercial electrostatic precipitator installed for iron ore sintering machine gas cleaning.

There are many additional serious problems in this field which can be grouped under this general discussion. The power requirements of the furnaces tie the power boiler into the scope of this study. These boilers in the steel mill are the catchall for waste fuel, and consequently may present any type of air cleaning problem or none. Fired with blast furnace gases these stacks will reflect the preliminary gas cleaning. Visually, these are of necessity reasonably clean as the dirt in these gases causes serious accretions in the boiler. If fired with coke breeze, a very simple gravitational type collection is visually adequate. Proper operation of stokers for coal firing usually results in acceptable stacks with no cleaning, and where required a simple mechanical collector is normally adequate. Where pulverized coal is fired, fly ash presents a real problem. This has been completely overcome in the power industry, and cleaning of these gases in the range of 95 to 98 per cent has become routine. Each of these must be analyzed separately as the ash from each coal has its own unique properties, both chemically and physically. Efficient cleaning of these gases can be achieved by either an electrical precipitator alone or in com-

Figure 8 — Flow diagram for iron ore sintering machine gas cleaning.



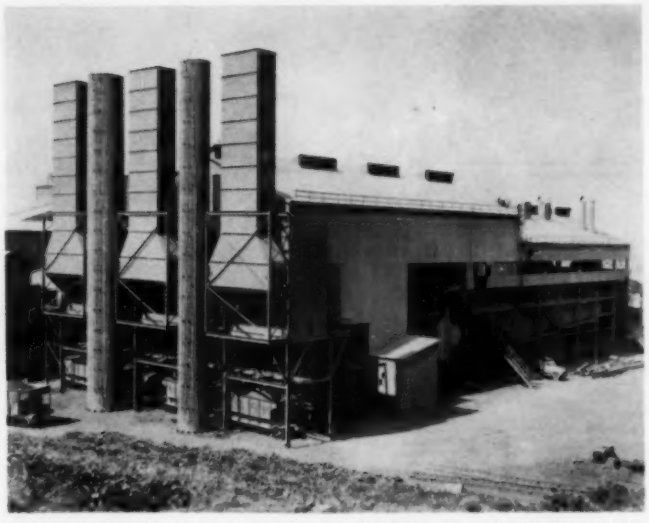


Figure 9 — First commercial installation of electrostatic precipitators for cleaning iron ore sintering machine gases.

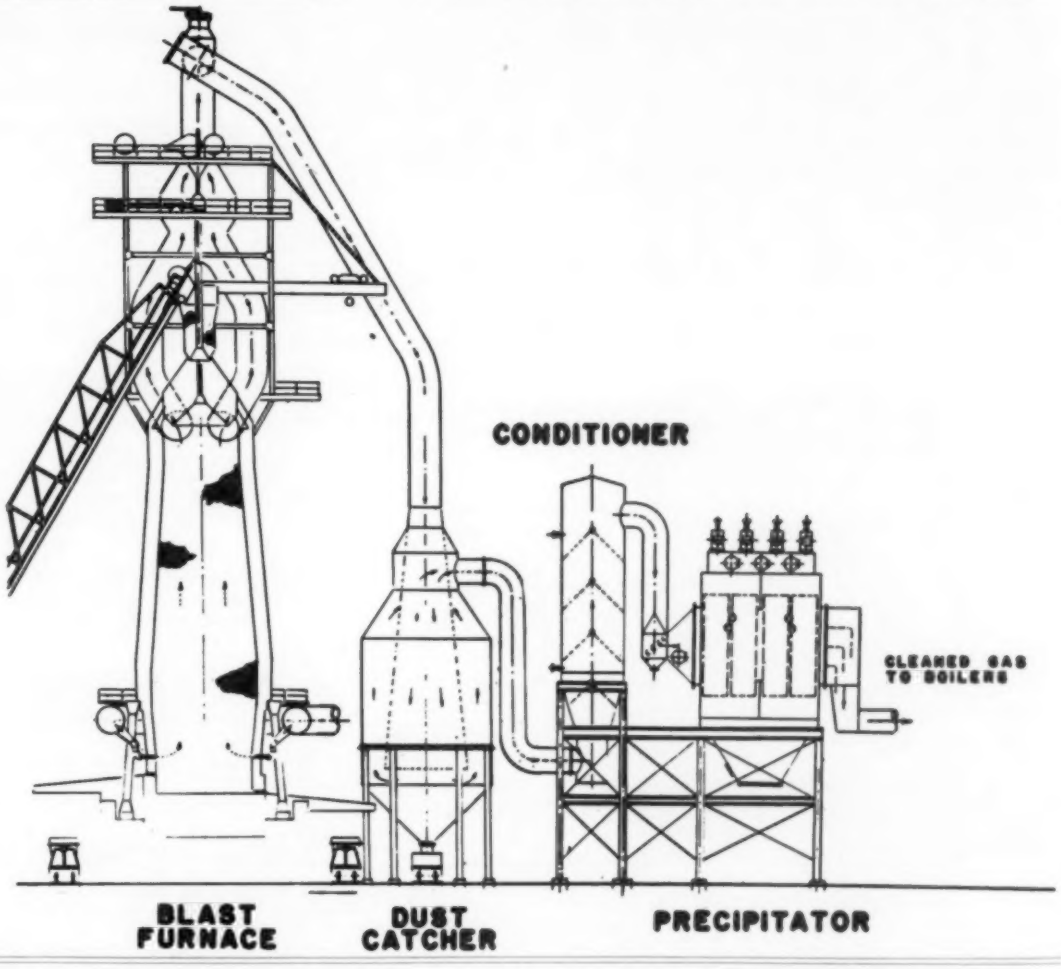


Figure 10—Flow diagram for dry cleaning ferromanganese blast furnace gas.

bination with a mechanical collector. The quantity of gases will vary with the excess air. This range is 12 to 20 lb of gas per kwhr. As much as 85 per cent of the ash in the coal will be carried to the stacks with fine grinding.

There are many other problems of less general interest. The production of ferromanganese or speigel entails the production of large quantities of true fume. These gases can be cleaned wet or dry. Sulphuric acid production presents no new technical problem in this field. Very few other operations are of general interest.

SUMMARY

In the foregoing we have tried to cover briefly the general aspects of the problems of gas cleaning in the steel industry which at present are of greatest interest to the engineers who must deal with air pollution control.

We believe that the progress made in the art of gas cleaning has been excellent. These results have been possible only by a completely coordinated effort of the steel industry and the gas cleaning industry. Both recognize the necessity for the art of gas cleaning to advance continuously. Failure to do so may delay important developments in steel technology. It may even make some appear impractical.

As in other technical fields, there is no such thing as a static condition. Progress has been and will be steadily made. We believe that as knowledge of this field increases, the demand for better and less costly gas cleaning equipment will also increase. We who specialize in this art accept this challenge from the steel industry and assure the industry that all of our talents are being directed toward that common goal.

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HOTEL STATLER, LOS ANGELES, CALIF.

PROGRAM

AISE western meeting

HOTEL STATLER
LOS ANGELES, CALIFORNIA

february 20, 21, 22, 1956

MONDAY, FEBRUARY 20

8:30 am — REGISTRATION

9:00 am — TECHNICAL SESSION — Sierra Room

Chairmen: E. C. Thomas, Works Manager, Pacific States Steel Corp., Niles, Calif.

W. T. Purvance, Works Manager, Columbia-Geneva Steel Div., United States Steel Corp., Provo, Utah.

"Developments in Scalebreaking and Continuous Pickling Lines," by J. I. Greenberger, Group Engineer, United Engineering and Foundry Co., Pittsburgh, Pa.

"Pipe Mill, Utah," by M. P. Klick, Chief Engineer, Consolidated Western Steel Div., United States Steel Corp., Los Angeles, Calif.

"Discussion of Gear Tooth Forms for Steel Mills," by John J. Stolz, Assistant Vice President Engineering, Tool Steel Gear and Pinion Co., Cincinnati, Ohio.

2:00 pm — TECHNICAL SESSION — Sierra Room

Chairmen: T. G. Simison, Assistant General Superintendent, Rolling Mills, Kaiser Steel Corp., Fontana, Calif.

J. M. Murphy, Assistant Works Engineer, Pittsburg Works, Columbia-Geneva Steel Div., United States Steel Corp., Pittsburg, Calif.

"Symposium on Continuous Annealing of Steel Strip"

"General Considerations," by Horace Drever, President, Drever Co., Bethayres, Pa.

"Furnaces," by C. E. Peck, Advisory Engineer, Industrial Heating Div., Westinghouse Electric Corp., Meadville, Pa.

"Mechanical Equipment," by H. W. Lynn, Sales Manager and M. D. Baughman, Jr., Assistant Chief Engineer, The Wean Engineering Co., Inc., Warren, Ohio.

"Electrical Drives," by E. B. Fitzgerald, Division Manager, Industrial Control Sales, Cutler-Hammer Inc., Milwaukee, Wis.

TUESDAY, FEBRUARY 21

9:00 am — TECHNICAL SESSION — Sierra Room

Chairmen: C. R. Lohrey, Assistant General Superintendent, Kaiser Steel Corp., Fontana, Calif.

G. W. Teskey, Jr., Superintendent Open Hearth, Bethlehem Pacific Coast Steel Corp., San Francisco, Calif.

"Recent Developments in Sintering and Pelletizing," by Edwin N. Hower, Manager, and John A. Anthes, Process Engineer, Industrial Dept., Dravo Corp., Pittsburgh, Pa.

"Some Methods for Analyzing and Controlling an Open Hearth Operation," by Eugene H. Swett, Fuel Engineer, Bethlehem Pacific Coast Steel Corp., South San Francisco, Calif.

"Design and Construction of Fontana Open Hearth Precipitators," by E. V. Akerlow, Project Engineer, Kaiser Engineers, Division of Henry J. Kaiser Co., Oakland, Calif.

"Method of Testing Open Hearth Precipitators," by J. H. Smith, Technical Engineer, and G. L. Rounds, Research Chemist Air Control and Research Dept., Kaiser Steel Corp., Fontana, Calif.

2:00 pm — TECHNICAL SESSION — Sierra Room

Chairmen: C. C. Brandt, Superintendent Electrical Dept., Bethlehem Pacific Coast Steel Corp., Los Angeles, Calif.

E. F. Donatic, Assistant General Superintendent, Kaiser Steel Corp., Fontana, Calif.

"Electrical Maintenance, Pueblo Plant of the Colorado Fuel and Iron Corp.," by Harold E. Watson, Electrical Superintendent, Pueblo Plant, The Colorado Fuel and Iron Corp., Pueblo, Colo.

"Tonnage Heating by Induction," by R. S. Segsworth, Director of Research, The General Engineering Co., Ltd., Toronto, Canada, and M. C. D. Hobbs, General Superintendent, Western Canada Steel Co., Vancouver, B. C., Canada.

E. C. THOMAS

W. T. PURVANCE

T. G. SIMISON

"Electric Drive Systems for Rod, Bar and Merchant Mills," by F. E. Fairman, III, Steel Mill Application Engineer, General Electric Co., Schenectady, N. Y., and A. C. Parsons, Steel Mill Engineering, General Electric Co., San Francisco, Calif.

7:00 pm — INFORMAL STAG DINNER — Pacific Ball Room

WEDNESDAY, FEBRUARY 22

Inspection Trip to Los Angeles Plant, Bethlehem Pacific Coast Steel Corp., Los Angeles, Calif. Buses will leave Hotel Statler at 8:30 am.

hotel reservations

Write direct for hotel reservations to Hotel Statler, Los Angeles, Calif., giving time of arrival and type of accommodations desired. Reservations should state that they are for AISE Western Meeting.

J. M. MURPHY

C. R. LOHREY

transportation

Individuals or groups desiring assistance in planning their trip should get in touch with the office of American Express Company in their respective cities, or with any local travel agency.

G. W. TESKEY, JR.

C. C. BRANDT

E. F. DONATIC

Abstracts of Technical Papers

to be presented at

AISE WESTERN MEETING

February 20, 21, 22, 1956

HOTEL STATLER

LOS ANGELES, CALIFORNIA

"DEVELOPMENTS IN SCALEBREAKING AND CONTINUOUS PICKLING LINES"

by J. I. GREENBERGER, Group Engineer, United Engineering and Foundry Co., Pittsburgh, Pa.

▲ PAPER develops importance of a proper mechanical scalebreaking process prior to acid pickling. Various mechanical scalebreaking methods such as cold rolling, stretching and flexing are mentioned.

J. I. GREENBERGER

A series of fundamental tests are discussed and the relationship between surface strain and resultant effectiveness of scalebreaking is established. The basic similarity of response of various types of hot mill oxides to the mechanical scalebreaking process is shown.

Design features of these scalebreakers are discussed, emphasizing flexibility and ruggedness. Several years of operating experience have more than confirmed original test predictions and a recent full scale field test showed excellent pickling of continuous hot mill type of oxide with less than 25 seconds of acid immersion after passage through the scalebreaker. Flexing rolls operate a month and backing rolls four to five months between grinds.

Having excellent scalebreaking means available, the fundamental relationships existing in the overall continuous pickling line are developed. The correlation between coil length, downtime, entry zone speed and pickle zone speed is analyzed and results developed which indicate the desirability of modifying entry ends of continuous pickling lines to a double entry looping pit arrangement.

Potentialities of combining good scalebreaking with double entry looping pits and shorter acid tanks are developed to show that reasonable entry speeds, high production and various economies are possible. Photographs of operating scalebreakers and shop views of a new 70-in. machine as well as a nomograph for establishing pickle line productions are presented.

In general, the paper offers solutions to the two related problems of scalebreaking and increased mechanical pickle zone speeds.

"PIPE MILL, UTAH"

by M. P. KLICK, Chief Engineer, Consolidated Western Steel Div., United States Steel Corp., Los Angeles, Calif.

▲ THE opening of a new large electric welded pipe mill in Utah was fittingly in the 100th year since the predecessor of this division of U. S. Steel was founded in the west. The forbear made pipe for the hydraulic mining industry in the mother lode country in the early days.

M. P. KLICK

The new mill on the railroad spur of Pipe Mill, Utah, makes two types of electric welded pipe. One is a large diameter submerged-arc-welded high strength line pipe. This is the sixth mill designed and built by Consolidated Western to build this type of pipe, which it pioneered.

The building of the mill was handicapped by very severe Rocky Mountain winter weather, more quicksand than anticipated by soil tests, and the usual difficulties with innovations in processing. Yet, the mill

began production seven months after ground was broken, to meet the schedule for one of the West's newest pipelines which is being built to serve the Northwest.

The general process has been covered in papers and articles published before, so that the principal subjects to be discussed are the innovations, including automatic features, U-ing and O-ing without edge forming, reversal of sequence of inside and outside welding, and improvements in the expander.

A tour of the plant by use of illustrations is planned to follow the paper.

"DISCUSSION OF GEAR TOOTH FORMS FOR STEEL MILLS"

by JOHN J. STOLZ, Assistant Vice President Engineering, Tool Steel Gear and Pinion Co., Cincinnati, Ohio.

JOHN J. STOLZ

▲ GEARS are a common method of transmitting power or rotary motion from one shaft to another. The invention of gear teeth represents a gradual evolution from gearing of primitive form. The earliest evidence we have of an investigation of the problem of uniform motion dates from the time of Olaf Roemer, who in the year 1674 proposed the epicycloidal form. The involute form as we use today was developed about the year 1740 by Leonard Oyler, Swiss mathematician.

The 14½-degree pressure angle gearing was adopted as a standard and is still in use today. It was selected back in the cast tooth era. The natural sign of the angle is approximately ¼ and is a convenient fraction for the gear engineer and pattern maker when laying out teeth. The 14½-degree system develops rather straight-sided teeth. Due to the slight pressure angle, gear tooth strength is sacrificed to some degree. This form in action gives fairly good results and it is not too critical from the standpoint of slight inaccuracies and mountings.

To get stronger and more refined gearing, the 20-degree pressure angle form was developed. This form produces greater curvature in the tooth and produces smooth tooth action. Gearmakers highly recommend its use generally.

In standard 14½- or 20-degree gearing, the gear is much stronger than the mating pinion. To get a closer relationship in strength betwen gear and pinion and also to refine the tooth action to a greater degree, long and short addendum gearing was developed.

This type gearing usually carries the basic 20-degree pressure angle. The pinion outside diameter is oversize and the gear outside diameter is undersize. Standard pitch diameters are maintained. This method of producing gears considerably strengthens the pinion and almost entirely eliminates undercutting below the pitch circle. The resulting tooth form is well rounded and gives smooth tooth action. It is particularly recommended on ratios of 3 to 1 or greater. This is true as on high ratios the number of teeth in the pinion is usually very small and standard pinions will undercut seriously, which affects smooth tooth action. This form is highly recommended on high speed drives or motor drives.

For better gear drives 20-degree pressure angle gearing in the standard form and the long and short addendum variation should be given every consideration.

"SYMPOSIUM ON CONTINUOUS ANNEALING OF STEEL STRIP"

"FURNACES"

by C. E. PECK, Advisory Engineer, Industrial Heating Div., Westinghouse Electric Corp., Meadville, Pa.

C. E. PECK

▲ A general discussion of design capacity and cycle as applied to continuous vertical strand annealing furnaces is covered. A typical high speed tin plate annealing line is described in detail, and design features of the principal components are discussed. These include an appraisal of various methods of heating, economics of heating, methods of temperature control, atmosphere control, and methods of cooling.

A comparison of designs, ranging in strip speed from 500 to 2000 fpm, and the problems relative to strip tracking and rethreading as a function of line speed are discussed.

Of special interest is a combustion and burner system for heating the strip at high strip speed at relatively low fuel consumption rates.

Various equipment features, such as the structure, the rolls, bearings, burners, cooling methods, etc., are covered. The function of the vertical strip annealing furnace in a continuous line is discussed and compared with horizontal type lines covering the limitations and applications of each type.

The problems associated with operation and maintenance of the furnace are also outlined and general experiences summarized.

"ELECTRICAL DRIVES"

by E. B. FITZGERALD, Division Manager, Industrial Control Sales, Cutler-Hammer Inc., Milwaukee, Wis.

▲ THE conventional adjustable voltage, continuous processing line, strip propelling drive must be modified and upgraded to satisfy the requirements for the continuous annealing of strip steel at high speeds. This paper, therefore, deals with those modifications and special features which would be incorporated into the stripping propelling drives of a hypothetical 2000 fpm continuous annealing line. The special requirements noted in this paper may be essentially segregated into four major classifications.

E. B. FITZGERALD

The first of these is a consideration of the required coordination between entry and delivery section drives to permit introduction and extraction of the coiled stock with sufficient rapidity so as not to affect the high operating speed of the line's annealing section.

Second, the hypothetical specifications require the cleaning of the strip prior to annealing and those steps which must be taken to integrate these two functions into a single continuous processing line are outlined.

Third, the reduced strength of the steel strip in the annealing furnaces requires utilization of many small helper motors instead of a few relatively large bridle or tension roll motors in the cleaning and annealing sections of the line. The coordination and regulation of these helper motors is analyzed and discussed.

Last, methods are developed for providing the required compensation in the electrical drive for changes in strip length caused by the heating and cooling of the strip steel in the line's annealing section.

"MECHANICAL EQUIPMENT"

by H. W. LYNN, Sales Manager, and M. D. BAUGHMAN, JR., Assistant Chief Engineer, The Wean Engineering Co., Inc., Warren, Ohio.

▲ ALTHOUGH the annealing furnace and its auxiliary equipment is the primary equipment factor to be considered in any continuous light gage strip annealing line, the success of an installation depends to a great degree upon the proper selection of mechanical equipment and its associated electrical equipment. The terminal equipment must prepare the strip and deliver an uninterrupted flow of material to the furnace, in order that maximum efficiency can be obtained under the most ideal operating conditions. Following the annealing operation, the equipment must also be designed to continually accept the annealed product and reform it into suitable coils for further processing in the mill.

For purposes of illustration, a hypothetical high speed, light gage, strip annealing line arrangement is presented, with comments offered on some of the design problems that are involved in building mechanical equipment to meet the operating line conditions. Although the various components of equipment that are incorporated in a continuous annealing line are similar to equipment utilized in other strip processing lines, many additional factors should be considered in selecting the equipment for this application.

The handling of the cold reduced coils at the entry end of the line is a key operation, with the most satisfactory method depending to a great extent upon coil size and the exact material flow arrangement to the line. With industry in general going to increased coil weights, the material handling problem at the entry end of the line usually resolves itself into drive conveyor systems or multiple storage coil saddles which are serviced by the coil holder cars. Proper consideration must be given to the handling of scrap coil ends, the rapid preparation of coils for welding, and the actual welding operation—all of which become increasingly important factors in high speed operation.

For many years the cleaning, rinsing, and drying of cold rolled strip before annealing has been a separate operation in mill processes. Many improvements have been made in these lines in the past ten years, and the experience gained must be incorporated into processing equipment for the continuous annealing line, with even further improvements required to meet the greater demands of speed and continuity of operation.

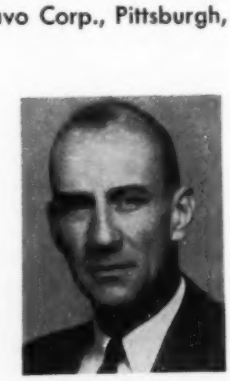
Since the annealing furnace requires a constant flow of strip for its most efficient operation, the method of accumulating material ahead of the furnace to permit entry end stoppage for welding and the means of collecting strip on the delivery side of the furnace to accommodate the coiler operations present many engineering and operating problems. High speed operation of multiple strand loopers or multiple free-hanging loops indicate limitations in the application of each type of strip accumulating system.

Although strip drive bridles and pinch rolls for high speed lines do not offer any major engineering or operating problems, some recent developments in their detailed construction are of specific interest for annealing line applications.

The operation of coilers at the delivery end of the line is quite comparable to equipment now in use on tin plate processing lines. However, the increased speed factor for the hypothetical annealing line dictates further consideration to the practice of transfer shearing, belt wrapping, coiler shifting, and delivery end coil handling.

"RECENT DEVELOPMENTS IN SINTERING AND PELLETIZING"

by EDWIN N. HOWER, Manager, and JOHN A. ANTHES, Process Engineer, Industrial Dept., Dravo Corp., Pittsburgh, Pa.



EDWIN N. HOWER

▲ THIS paper discusses recent improvements in sintering and pelletizing techniques with particular emphasis on certain developments which originated in Europe and which are now being adopted in the United States. The paper is divided into two main parts, sintering improvements and pelletizing improvements. The sintering improvements are classified into four classes:

Improvements due to increased rates per unit area as a result of getting more air through the bed. A second improvement has been in the use of larger sinter machines, reducing the number of units necessary for large scale production of sinter. Improvements have also been made in durability of both the sinter ma-

chines and auxiliary equipment. A fourth class of improvements is those which have improved the quality of the sinter produced.

JOHN A. ANTHES

The portion of the paper on pelletizing contains a brief discussion of the factors which dictate the use of pelletizing rather than sintering. The discussion of pelletizing is divided into two main classifications, improvements in pellet formation and improvements in pellet sintering.

The paper is illustrated with photographs and drawings.

"DESIGN AND CONSTRUCTION OF FONTANA OPEN HEARTH PRECIPITATORS"

by E. V. AKERLOW, Project Engineer, Kaiser Engineers, Division of Henry J. Kaiser Co., Oakland, Calif.

▲ THIS paper discusses the salient features of the design and construction of the electrostatic precipitators that have been installed by Kaiser Engineers on two of the open hearth furnaces of the Fontana plant of Kaiser Steel Corp.

In tracing the developments which led to the successful installation on No. 9 furnace, which was the second of two percipitators installed, the author begins with a general discussion of the air pollution situation in San Bernardino County and its adherence to the regulations of the Air Pollution Control District of adjacent Los Angeles County. Studies of the control of air pollution at Fontana are now conducted under the auspices of the air control and research department of the company. It is Kaiser Engineers' job to coordinate equipment design data with these studies.

The precipitator for No. 3 furnace was the first dust control equipment installed on an open hearth furnace in this country. Many types of dust collection equipment were considered resulting in the ultimate selection of an electrostatic unit. The operation of the original installation of No. 3 precipitator was studied for approximately nine months resulting in the definition and solution of several important problems. Many basic changes were made in No. 3 precipitator which brought its operation up to design efficiency.

As a direct result of the work on No. 3 furnace, the precipitator operating criteria was established to handle the effluent from No. 9 furnace. The reasons for locating the precipitator on the roof of the open hearth shop, and the solution of the attendant problems are discussed.

It was necessary to reinforce the precipitator, strengthen the discharge and collection electrode systems, and install a distribution section ahead of the electrostatic field. The importance of residence time of the gas in the electrostatic field is pointed up as well as the sequence and type of rapping for overall precipitator efficiency. The reasons for selecting selenium rather than mechanical rectifiers are brought out.

The key points of design of No. 9 precipitator not only are being used in the current installation of precipitators 4 and 5, but also they are presented in this paper as basic data of value to the industry as a whole.

"METHOD OF TESTING OPEN HEARTH PRECIPITATORS"

by J. H. SMITH, Technical Engineer, and G. L. ROUNDS, Research Chemist, Air Control and Research Dept., Kaiser Steel Corp., Fontana, Calif.

J. H. SMITH

▲ THE author's explain the methods and equipment used while testing the second precipitator installation in the open hearth shop of Kaiser Steel Corp. The advantage of the use of punched card machines for handling the laborious computations involved in obtaining reliable flow distribution curves is explained. The discussion also brings forth a few of the anomalies existent in such a testing program.

G. L. ROUNDS

The second precipitator incorporated a number of innovations which had not been used in the previous installation. As a result, several organizations were vitally interested in the performance of the new precipitator. It was resolved that all concerned would combine their efforts in one comprehensive testing program. This paper outlines the resultant program.

"ELECTRICAL MAINTENANCE, PUEBLO PLANT OF THE COLORADO FUEL AND IRON CORP."

by HAROLD E. WATSON, Electrical Superintendent, Pueblo Plant, The Colorado Fuel and Iron Corp., Pueblo, Colo.

HAROLD E. WATSON

▲ THE electrical department at the Pueblo plant of the Colorado Fuel and Iron Corp. is responsible for electrical maintenance in all operations, supervision and coordination of all electrical construction, operation of the electric shop, and supervision of electric cranes.

The Pueblo works of the Colorado Fuel and Iron Corp. is a diversified plant consisting of a coke plant, blast furnaces, open hearth, rail mill, 40-in.

blooming mill, 20, 25, 14, and 10-in. merchant mills, a rod mill, seamless tube mill, and wire mill. Electrical maintenance, then, covers the full scope of such problems in the steel industry. The approach to these problems from the standpoint of organization and training raises some provoking questions.

Construction is supervised and coordinated in such a manner that the supervisors who will be responsible for maintenance are familiar with equipment from the time of its conception and installation.

The electrical department is intimately concerned with the selection and design of electrical equipment and works closely with design engineers.

The inclusion of electrical inspectors and cranemen in plant-wide seniority units has introduced many labor-management problems in addition to the inherent advantages of such an arrangement. The use of an electrical bull gang for construction and emergency maintenance has been a desirable arrangement.

Although the department is responsible for all maintenance and construction, including control of spares, it operates with a minimum of clerical or office overhead, and there is a decided lack of procedural formality.

The organization of the electrical department at the Pueblo plant includes a comprehensive apprentice program for electricians of all categories.

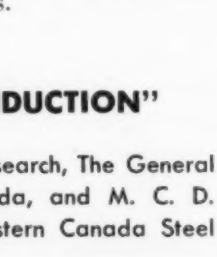
The overall plant organization at the Colorado Fuel and Iron Corp. requires the superintendent of the department to function in a variety of plant-wide committees and programs.

The key to efficient operation of an electrical department has been found to be in the proper selection and training of personnel.

Maintenance costs have been held to a minimum in face of industry-wide wage increases.

"TONNAGE HEATING BY INDUCTION"

by R. S. SEGSWORTH, Director of Research, The General Engineering Co., Ltd., Toronto, Canada, and M. C. D. HOBBS, General Superintendent, Western Canada Steel Co., Vancouver, B. C., Canada.



R. S. SEGSWORTH

▲ THIS title has been selected to direct attention to those applications of electrical induction heating where the part is heated throughout, as for forging, extrusion, rolling and through heat treating, and where the sizes and qualities involved justify the use of low and medium frequencies.

Data are given to show the potential field of applications, based primarily on economical considerations, but including reference also to some applications which from a technical point of view, may best be handled by the induction method.

Two typical installations are described, where the low and dual frequency induction heating methods have been applied, and in which many tens of thousands of tons of steel have already been heated.

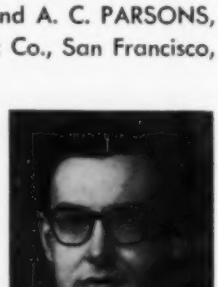
M. C. D. HOBBS

One application is heating 6-in. square mild steel ingots to forging temperature at the rate of about 4 tons per hour. Cost and performance are given on this operation in comparison with the rotary hearth furnace used previously.

The second example is an ingot heating furnace in a rolling mill. This is at present the largest single induction heating unit in the world, and the paper describes the unit in a general way, refers to some of the problems encountered and gives some operating data which is compared with previous experience, in this case with manually charged fuel-fired batch furnaces.

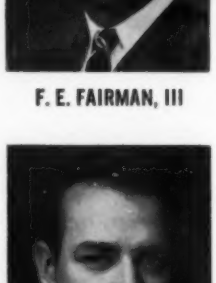
"ELECTRIC DRIVE SYSTEMS FOR ROD, BAR AND MERCHANT MILLS"

by F. E. FAIRMAN, III, Steel Mill Application Engineer, General Electric Co., Schenectady, N. Y., and A. C. PARSONS, Steel Mill Engineering, General Electric Co., San Francisco, Calif.



F. E. FAIRMAN, III

▲ A new type of electric drive system for rod and bar mills has been applied on several recent mills. In addition to the use of mercury-arc rectifier power supplies, the new system uses standard mill type motors with speed regulators for each main drive, principally to reduce the looping and stretching of material caused by impact speed drop drive when material enters or leaves a stand.



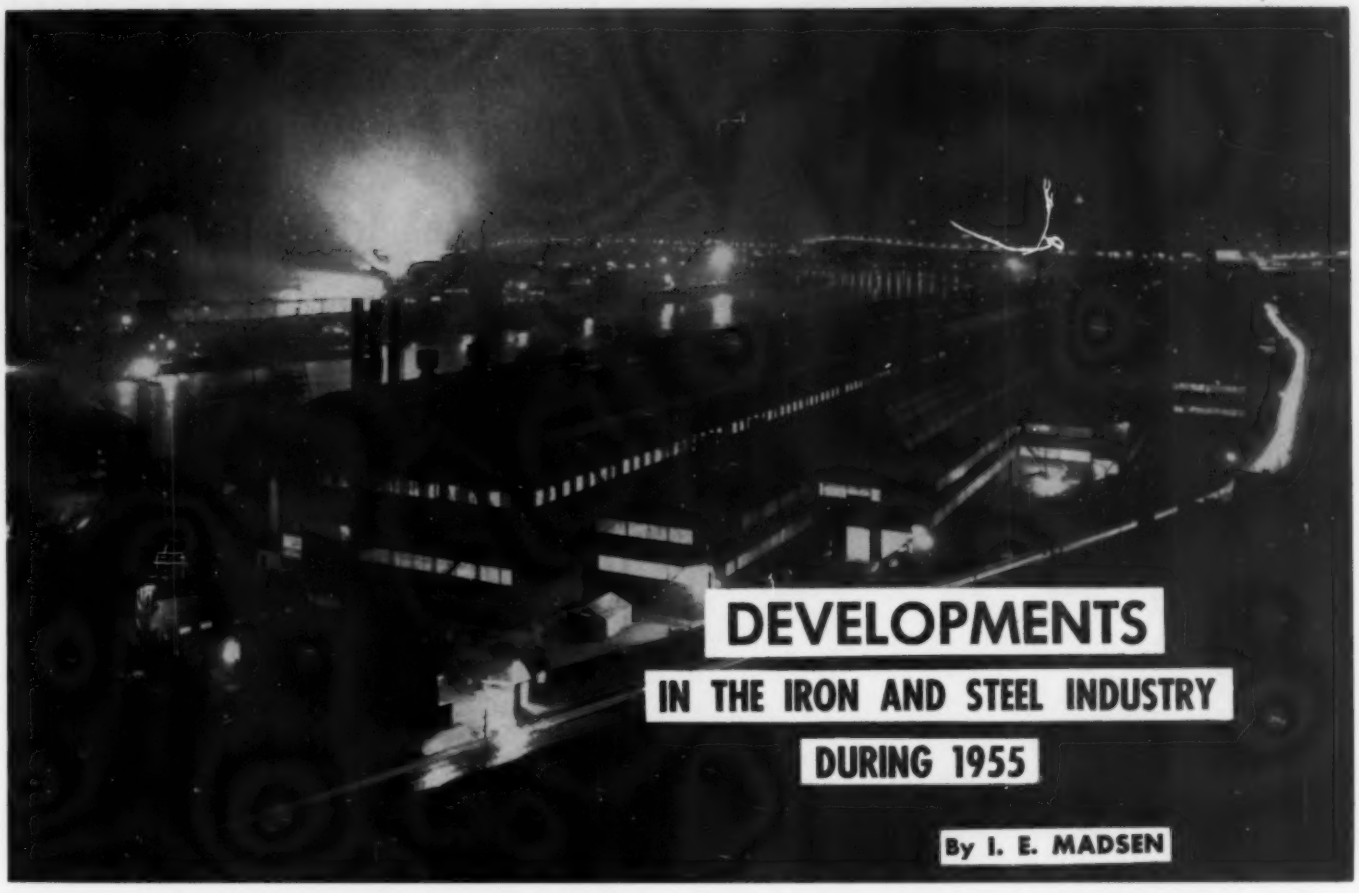
A. C. PARSONS

Each speed regulator compares a reference voltage to the voltage of a tachometer generator driven by the main drive motor. The signal is amplified by magnetic amplifiers, connected in push-pull, and applied to the control fields of a rotating amplifier connected in series with the motor shunt field.

Advantages of the speed regulator system over the conventional system are:

1. Faster recovery from impact loads.
2. Improved steady-state speed regulation.
3. Fast response to vernier adjustments.
4. Minimum speed drift over long periods.
5. Reduced cost of electrical equipment.

The main drive motors for one rod mill are of a totally enclosed water-air-cooled construction. The complete self-contained ventilating system includes blowers, surface air cooler, and air filters. It is estimated that an average overall saving of $25,000 per motor was saved due to the simplified construction of the motor foundation.



DEVELOPMENTS IN THE IRON AND STEEL INDUSTRY DURING 1955

By I. E. MADSEN

The steel industry had to work night and day in its efforts to keep up with demand for steel.

▲ THE year 1955 was a good one for steel. It was a year of full production with demand heavy for all products. Thus it was possible to schedule orders efficiently and the resulting operating and financial statements for the year showed record or near record profits. Except for a slight break during the summer as a result of a one-day strike, production generally held up at almost 100 per cent of capacity throughout the year. It was a good year also in that labor troubles were at a minimum. At the end of the year the industry found itself booked solid for the first quarter with no let up in demand in sight.

Steel production in the United States in 1955 was estimated at 117,000,566 net tons or 93.0 per cent of the January 1, 1955 capacity. This is equivalent to an index of production of about 139.7 per cent. Of this, open hearth production totaled about 105,342,886 tons or 95.6 per cent of capacity; bessemer production totaled 3,319,088 tons or 69.3 per cent of capacity, and electric furnace production totaled 8,338,592 net tons or 77.2 per cent of capacity. Of the total steel produced, 90.0 per cent was made in the open hearth, 2.8 per cent was made in the bessemer, and 7.2 per cent was made in the electric furnace. Compared with last year, the electric furnace share was up about 1 per cent and the open hearth was down about 1 per cent.

These figures compare with a total of 88,311,652 tons in 1954 or 71.0 per cent of capacity, of which open hearth steel was 80,327,494 tons or 73.6 per cent of capacity; bessemer was 2,548,104 tons or 53.2 per cent of capacity; and electric furnace was 5,436,054 tons or 52 per cent of capacity.

B'ast furnace production in 1955 totaled about 77,646,415 tons or about 92.4 per cent of capacity, based on the January 1, 1955 capacity of 83,971,100 net tons. This compared with production in 1954 of about 58,688,117 tons or 71.6 per cent capacity. Estimated in the 1955 figure are about 681,000 net tons of ferromanganese and spiegeleisen. Coke production in 1955 totaled about 80,000,000 tons compared with 61,000,000 tons in 1954. Finished steel production in 1955 was about 85,000,000 tons compared with 64,000,000 tons in 1954. Although total steel production increase was about 33 per cent, output of alloy and stainless steel rose 45 per cent from 7,150,000 tons to about 10,650,000 tons.

The steel turned out in 1955 represents a production rate greater than any previous year, superseding the 111,600,000-ton record of 1953. The continuing demand for steel in 1955, a peacetime year and a year unaffected by war, has resulted in many announcements of new additional capacity and expansion plans by steel pro-

ducers. These expansion programs are enormous and reflect the optimism of steel plant management that this country not only will keep on growing but that per capita use of steel will also increase as well. These plans foresee more and better uses for steel, they see industry requiring more and more metal, they see more and more steel needed for the better things of life and the higher standard of American living.

The announcements of these plans were scattered throughout the year, but there was a heavy rush toward the year-end. These reflected a tendency on the part of some managements not to let themselves get behind the trend. One factor which may have held back these announcements was the uncertainty as to whether the government would approve quick amortization for additional projects. When the ODM decided to shut off quick amortization, it had on file 66 applications which covered steel expansion costing about $1,100,000,000. At this time also, ODM denied quick write-offs to the aluminum industry which had plans for expansion costing over $423,000,000, for which fast write-offs had been requested. With minor exceptions, plans which may have been held in abeyance were released as soon as steelmakers could see some way towards financing them themselves. It is possible of course that other plans may have been shelved.

The financing of additional steel capacity and improvement of existing facilities is one of the most difficult problems steel management has to face today. Three sources are being generally used for such financing: the retention of earnings, loans and higher prices. Of these three, retention of earnings has been helped by the quick amortization of existing new facilities. There were no appreciable price increases other than to cover the wage increase, except on a few items such as structurals and plates, but there was much talk of the necessity of general price increases at the end of the year.

One of the main reasons why the steelmaker wants price increases in spite of high profits and high operating rate is that existing depreciation rates are not realistic. Such rates as allowed by the government are based on a 30-year period, and average from $6 to $7 per ton of annual capacity. With new steel capacity estimated to cost $300 to $325 per ton it requires from $10 to $11 depreciation to return the investment. This does not take into account any future inflation or increases in cost of steelmaking facilities. Past records would lead only to planning on the basis of higher prices in the future.

Another factor which will make it more difficult to increase capacity is that over the past few years much of the increase in capacity was obtained through enlargement and improvement of existing facilities. This type of expansion can be done most economically since maximum use is made of existing facilities, equipment, transportation, buildings, utilities, etc. This particular method has been carried as far as possible in some plants. Additional capacity must soon require new units and perhaps new sites.

As an example, when the new expansion program was announced for National Steel this year, it was estimated that the additional million tons of steelmaking capacity would be obtained at a cost of $200,000,000 or $200 a ton. Capacity at the Weirton plant will be increased through the addition of a 600-ton furnace and iron capacity will be increased through use of sinter burdens and oxygen. However, due to the limited space available, this is about the end of the expansion which can be obtained at Weirton.

Another factor in proposed expansion programs is a different approach on the part of the steelmaker to such expansion programs. Heretofore, expansions have been set up to meet a sudden need in demand or emergency requirement such as necessitated by World War II and the Korean War. The view point that expansion is normal, that it will be a never-ending function, is one which is now finding favor on the part of management. Therefore additional investment capital must continuously flow into the steel industry to make such expansion possible and this underlies the pressure for higher prices and more realistic depreciation policies.

Figures for estimated cost for additional capacity vary even for integrated plants because of variations in what is included in such a unit. Benjamin Fairless testified in a hearing that the Fairless Works cost $300 a ton, including the iron ore development in Venezuela. Arthur B. Homer testified that when raw material was available, steelmaking capacity cost about $250 a ton. Additional capacity in an existing plant can be obtained at costs as low as $100 per ton.

Admiral Ben Moreell of Jones & Laughlin Steel Corp. estimated that about 10,000,000 ingot tons of additional capacity can be obtained by expanding or rounding out existing installations at about $150 per ingot ton. Capacity above this must be built from the ground up.

In a report issued by the Business and Defense Services Administration during the summer, industrial mobilization planners were told that the ingot capacity by 1960 would be 150,000,000 tons. To meet this requirement, the steel industry must add 5,500,000 ton capacity each of the next four years. This estimate assumes that existing steel capacity is about 9,000,000 tons behind requirements, and that current civilian demand is about 117,000,000 tons, defense requirements 18,000,000 tons, necessitating 135,000,000 tons capacity. For a while it was believed that this report would result in a decision for quick tax write-offs. However, this did not take place.

Estimates for future expansion beyond this point vary widely. In one such estimate the 1970 population is expected to reach 200,000,000 and gross national product to go from $370,000,000,000 to $570,000,000,000. Based on this, ingot capacity at the end of fifteen years should be 185,000,000 tons and to meet this it will be necessary to expand about 4,000,000 tons a year for the next fifteen years or an increase of about 50 per cent for the whole steel industry. This would require that steel industries spend $18,000,000,000, or $1,200,000,000 a year for the next fifteen years, using a figure of $300 per ton. This estimate is also based on average steel ingot consumption of 1850 pounds per person in 1970 compared with 1535 pounds in 1955 and 1300 pounds in 1950.

Other estimates on expansion requirements range down to 2,000,000 tons per year.

In addition to the new capacity, if it is assumed that

existing capacity must be replaced over the next 30 years, this will require another 4,000,000 tons per year with accompanying capital expenditures.

Another factor which will affect steel expansion is the ability to obtain necessary equipment. Early in the year, steel companies approved expansions knowing that early delivery of equipment could be obtained. By the end of the year, however, orders on equipment builders had increased at such a rate that delivery schedules moved back up to two years.

At the beginning of the year, steelmaking capacity totaled 125,828,310 tons of ingots. Blast furnace capacity was 83,971,100 net tons and coke capacity (including beehive) was 72,684,750 net tons. Steel capacity totaled 128,363,090 tons on January 1, 1956, an increase of 2,534,780 tons. Blast furnace capacity increased 1,514,130 tons to 85,485,230 tons. Byproduct coke plant capacity was rated at 69,416,400 tons as of January 1, 1956 compared with 69,377,250 tons twelve months before. This latter figure applies only to byproduct coke capacity of iron and steel producers. Beehive oven capacity on January 1, 1955 had been 3,307,500 tons.

Where will the new expansion take place? Based on present estimates, most of it will be in the area between the Great Lakes, the Ohio River, the Pennsylvania border and the Mississippi River. Plants on the lakes have a number of advantages over other sites, because of transportation and availability of water.

The steel industry is still moving west. The latest survey by the American Iron and Steel Institute placed the geographical center of steelmaking in Ohio, 6 miles south of Beaver Dam.

Contrary to the westward trend of steel, a new 500,000-ton non-integrated steel mill appears as a possibility in Massachusetts. A Massachusetts' legislature commission issued a report recommending that such a mill be located at Fall River, Mass. The mill would use scrap steel and a continuous casting process.

Northeastern Steel Corp. is also expanding. This company bought the Stanley Works at Bridgeport Conn., and plans are underway to raise capacity from an initial 188,000 to 300,000 tons per year. Two 35-ton arc furnaces will provide the major steelmaking capacity.

Another New England development was an announcement during the year that Jones and Laughlin Steel Corp. purchased a site for a plant at Willimantic, Conn.

Important factors in the demand for steel in 1955 were the construction and automobile industries. The automobile industry set a record of about 8,000,000 cars, which required about 19,000,000 tons of steel. Value of new construction placed during 1955 was about $42,000,000,000.

Construction in 1956 is expected to break the 1955 record. Estimates indicate $44,000,000,000 for new construction, compared to $42,000,000,000 in 1955.

The railroads should provide a good market for steel in the coming year. As an example of the type of work being considered, the Pennsylvania Railroad estimated that the nation's railroads must spend at least $20,000,000,000 for capital improvements in the next ten years. Total orders for new cars in 1955 were about 161,800, the largest for more than 30 years.

The pipeline program is still tremendous and provides a major outlet for steel plate production. A large number of units are either planned or authorized.

Electrical steel producers are also finding that demand is strong. It is estimated about 815,000 tons were shipped in 1955 compared with the record of 820,000 tons in 1953. Producers of this steel are expanding continuously and Armco has a $25,000,000 program in Butler, Allegheny Ludlum completed a substantial program at its plants, and the Vandergrift Works of U. S. Steel underwent a rebuilding program.

Crucible Steel Co. and Allis-Chalmers Manufacturing Co. set up a new company to be called Silicon Steels, Inc., for the manufacture of grain-oriented steels. Finished product capacity will be about 1500 tons a month. The mill will be used for cold reducing stainless and titanium strip as well. A new cold mill will be able to handle material up to 36 in. wide, and from 0.080 to about 0.014 in. thick. Some production was underway at the end of the year.

The demand for tinplate also increased during the year, and about 5,800,000 tons were shipped in 1955 compared with 5,660,000 tons in 1954.

The can companies are setting their sights on finding some method of eliminating tin in metal cans for foods and other products. Steel is still the leading candidate because it is the least expensive metal to meet the needs of the 35,600,000,000 metal cans produced per year in the United States. Rust-resistant, chemically-treated steel (CTS), which is produced by processing steel through special solutions which alter surface chemistry, is one possibility. Results are encouraging. One of the troubles with this material is that it is not easily soldered. Where sterilizing is not a factor, such cans are made with cemented side seams. Nickel plated steel has also been considered for cans and has one advantage in that it can be soldered readily.

On the other hand, aluminum is cutting into some of the markets where iron and steel have been used. In the average passenger car, the use of aluminum has

Continuing expansion on ore unloading facilities is a must to keep up with the increased consumption by the mills.

gone up to 30 lb in 1955 models, reflecting a trend over the past few years. Aluminum is found in such items as automatic transmissions and engine components. Automotive trim also offers possible applications, and the new color finishes in aluminum may take over some of these markets.

Aluminum foil is also continuing its steady growth and production in 1955 was approximately 30 per cent over the 137,600,000 pounds produced in 1954. This has also been reflected in the new foil mills ordered and constructed during the year.

Steel companies are diversifying their products in many cases. As one example, Lukens Steel Co. changed its company charter so as to be able to manufacture both metal and non-metal substances and render services incidental to such manufacturing activities. Republic Steel formed an international projects division which will handle requests from foreign industries for technical engineering and manufacturing know-how.

Barium Steel Corp. integrated all its steelmaking operations under the management of Barium's subsidiary Phoenix Iron & Steel Co. at Phoenixville, Pa. This consolidation integrates Central Iron & Steel Co. at Harrisburg, known as the plate division, the Chester Blast Furnace, Inc. at Chester, Pa., now known as the blast furnace division, the structural division at Phoenixville, Pa. and Phoenix Steel Tube division also at Phoenixville.

On July 1, 1955 the basic steel industry and the United Steel Workers of America reached an agreement to increase minimum wage rates by 11.5 cents to a minimum rate of $1.685 per hour. The increments between job classes were increased to 6¢ from the previous 5.5 cents. The top job classification, number 32, now carries a scale of $3.55 cents per hour and the average weighted increase in steel industry was about 15¢. In this agreement, changes were made only in wages, as that was all that was open for discussion this year. When the contract ends in 1956, it is expected that the steelworkers will go after the guaranteed annual wage which was granted this year in the automobile and some other industries.

As a result of the wage increase, price increases were made that averaged about 5.8 per cent or $7.62 a ton. This increase should cover the wage increase as a rough figure on wage increases is that every cent increase in wages means a rise of 40¢ a ton in the price of ingots. Of this, half or 20¢ is direct expense, since it takes about 20 manhours on the average to produce a ton of ingot. The other 20¢ comes from the price increases in the materials which the industry must buy.

The industries payroll, excluding mining and non-steelmaking operations, was a record at $3,500,000,000.

An unusual development in prices is a new type pricing system which is being tried by Northeastern Steel Co. at Bridgeport. Under this system, the company will tie in its hot-rolled strip quotations to the cost of steel scrap. The base for their price will be $26.50 for No. 1 heavy melting scrap, and each dollar increase in scrap cost will add a dollar to the selling price of hot strip.

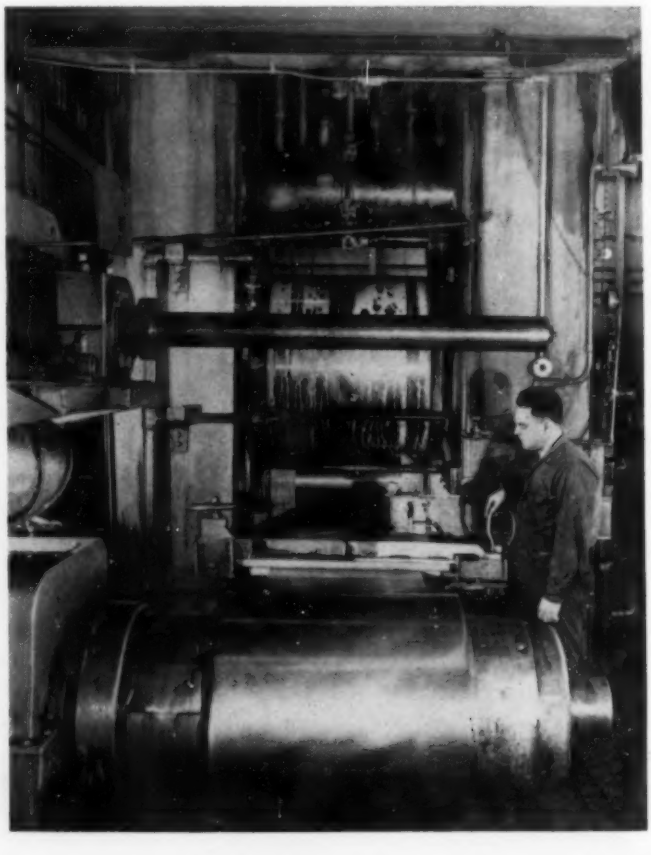
Developments in the transportation field met a setback during the year when Congress dropped the $95,000,000 Delaware River project. This project would deepen the ship channel serving the Fairless Works, but was killed in committee. However, work proceeded fairly rapidly on the new St. Lawrence Seaway. This project will combine navigation and power development. Present plans contemplate a power development of 1,900,000 kw. New waterways are to be able to handle ore carriers up to 25,000 tons capacity which is ten times the present limit.

Increasing imports of ore from foreign sources such as the new Venezuela development is creating a problem in the availability of ore carriers to handle the ores.

Three ore carriers which are carrying ore from Venezuela to the United States are rated at 60,000 tons capacity, and are probably the largest cargo carriers in the world.

The Defense Department issued a new standard on marking under their MIL 183. This sets standards for continuous marking of iron and steel products, but its use has met with some objections because of the production problems involved. The marking system is primarily concerned with high alloy steels, particularly bars, extrusions, plate, sheet, strip and tubular products. Under it, the producer's name and trade mark and a commercial designation must be stamped, printed or otherwise marked clearly in constantly recurring symbols not farther apart than 3 ft along the length of the product. In the case of alloy steel sheet and plate, more than one row of markings may be required, depending on the width. Material under ¼ in. outside diameter need not be marked. The markings are to include the AISI or other recognized specification numbers plus data on temper or other physical conditions.

The development of manufacturing facilities for new metals is necessitating installation of rolling facilities such as the unit here shown cold rolling 36-in. wide titanium strip-sheet.



DETAILED EXPANSION

Expansion of facilities is a chore which constantly faces steel plant management and engineers. No sooner is a plan made and approved before changing conditions make revisions or additions desirable. As a result, to tabulate or list the expansion program of the industry is a hopeless task. Such a tabulation is out of date the day after it is prepared.

The tabulation included here has been obtained from official company releases, annual financial statements, discussions with individuals, etc. Only the larger items are listed. They are items which were either under construction or on the construction schedule for 1955. Items which have a (C) after them were completed in 1955. Items and costs have been allocated against a plant location when possible.

PARTIAL LISTING OF ANNOUNCED EXPANSION PLANS — 1955

(C) Denotes completion in 1955*

Company and plant	Cost	Additional ingot capacity, tons	Steelmaking facilities	Additional iron capacity	Ore preparation	Hot mills	Cold mills	Finishing facilities	Miscellaneous
U. S. Steel									
Chicago Area	.....	1,500,000	.....	.....	.....	.....	.....	.....	.....
Geneva	.....	380,000	.....	.....	.....	Pipe mill (C)	.....	.....	.....
Other Plants	.....	620,000	.....	.....	.....	.....	.....	.....	.....
Fairless	$150,000,000*	.....	4-O.H.*	1-Blast furnace*	Sintering line	.....	.....	Miscellaneous	.....
Irvin	.....	.....	.....	.....	.....	.....	.....	Enamel sheet	.....
Youngstown	$ 2,500,000	.....	.....	.....	.....	.....	.....	.....	Special ingot mold
Vandergrift	.....	.....	.....	.....	.....	.....	Sendzimir	Anneal and pickle	Stainless and silicon lines
Gary	.....	.....	.....	.....	.....	.....	.....	Annealing furnace	.....
Houseville	$ 25,000,000	.....	.....	.....	Sintering line	.....	.....	.....	.....
Homestead	.....	.....	.....	.....	.....	.....	.....	.....	4-3-hole soaking pits
T.C. & I.	.....	.....	.....	.....	.....	.....		Electrolytic tinning line (C)	.....
A.S. & W.	.....	.....	.....	.....	.....	Rod mill	.....	.....	.....
National Tube	.....	.....	.....	.....	.....	.....	.....	.....	1-39 over coke battery (C) 1-59 over coke battery
Bethlehem Steel	$200,000,000	.....	.....	.....	.....	.....	.....	.....	.....
Bethlehem	.....	.....	.....	.....	.....	Structural	.....	.....	.....
Johnstown	.....	.....	.....	.....	.....	Rod	.....	.....	.....
Lackawanna	.....	.....	O.H. Improvement	.....	.....	.....	.....	.....	.....
Sparrows Point	$100,000,000	.....	.....	.....	Sintering line	160-in. Plate Electric weld pipe	5-Stand 48-in. 2-Stand, 4-high skin pass	2-Cont. annealing lines 2-Electrolytic tinning lines 2-Cont. galvanizing lines	.....
Steelton	.....	.....	.....	.....	.....	.....	.....	.....	Coke oven battery
Republic	$130,000,000	.....	.....	.....	.....	.....	.....	.....	.....
Cleveland	.....	732,000	2-O.H. 4-O.H. imp.	.....	.....	Slabbing	.....	.....	Soaking pits Slab furnaces
Warren	.....	336,000	2-Electric	.....	.....	.....	3-Stand, 42-in., tandem	6-Annealing lines	2-Row soaking pits
Youngstown	.....	70,000	.....	.....	.....	.....	.....	.....	.....
Chicago	.....	312,000	3-Electric to be replaced with top charge	.....	.....	22-in. Bar 10-in. Bar	.....	.....	.....
Gadsden	.....	168,000	1 or 2 Electric	.....	.....	54-in Hot strip	54-in., 3-Stand tandem 54-in. Temper	48-in. Cont. galvanizing Cont. pickle line	Soaking pit Slab heating furnace
Buffalo	$ 800,000	.....	.....	.....	.....	.....	.....	.....	Soaking pits
Massillon	.....	.....	.....	.....	.....	.....	.....	.....	31-Oven coke battery
Jones & Laughlin	$250,000,000	.....	.....	.....	.....	.....	.....	.....	.....
Aliquippa	.....	400,000	2-Oxygen converters	.....	Sintering	44-in. Hot strip 2-CW pipe 1-Electroweld pipe 1-Stretch reducing	.....	.....	Oxygen plant Soaking pits
Pittsburgh	.....	.....	.....	.....	.....	Hot extrusion (C)	.....	1-Galvanizing line	1-Coke oven battery
Cleveland	.....	300,000	2-Electric furnaces	.....	Sintering	1-Bloomer Hot strip revamp 1-Reversing rougher	4-Stand tandem	Annealing	Soaking pits
Willimantic, Conn.	.....	.....	.....	.....	.....	.....	Cold finish bar	.....	.....
Youngstown Sheet & Tube	$120,000,000	.....	.....	.....	.....	.....	.....	.....	.....
Indiana Harbor	.....	.....	.....	.....	.....	1-Seamless tube	4-High, 2-stand temper	1-Electrolytic tinning 3-Shear lines	76-Oven coke battery (No. 4) Annealing furnaces
National Steel	$270,000,000	.....	.....	.....	.....	.....	.....	.....	.....
Great Lakes	.....	550,000	.....	30-Ft. Blast furnace (C) Oxygen enrichment	1-12-Ft. Sintering machine (7000-ton capacity)	.....	.....	.....	78-Oven coke battery

PARTIAL LISTINGS OF ANNOUNCED EXPANSION PLANS—1955

(CONTINUED)

Weirton	.....	450,000	1–600-ton O.H.	.....	1–8-Ft. Sintering machine 1–12-Ft. Sintering chine (6,000-ton capacity)	54-in. HotStrip (Rebuild) (C)	5-Stand tandem, 54-in., 4-High, sheet	No.4 Electrolytic tinning (Planned); 1–Pickling line; No. 2 Galvanizing (C) 1–Cont. annealing line	41-Oven coke battery 3–Slab furnaces (C)
Inland									
Indiana Harbor	$260,000,000 $ 45,000,000	800,000 200,000 (C)	3–315-Ton O.H.	400,000 Tons (C)		W.F. Structural, Bloomer	Cold roll sheet dept.	No. 3 Galvanizing (C)	1–87 Oven coke battery 1 Office building
Armco	$130,000,000	.....	.....	.....	.....	.....	.....	.....	.....
Middletown	.....	720,000	4–275-Ton O.H.	.....	.....	.....	1–Temper mill	Aluminum and zinc coating line	.....
Butler	.....	.....	.....	.....	.....	7-Stand, 56-in., hot strip 1–Wheel mill Bar mill	.....	Anneal and pickle line	.....
Baltimore	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ashland	.....	.....	.....	.....	1–6-Ft Sintering line	.....	1–Reversing	Normalize and pickle	.....
Sheffield Div.	.....	456,000	.....	Enlarge blast furnace	1–Sintering line and ore bedding system	.....	.....	.....	.....
Allegheny Ludlum	$ 10,000,000	.....	.....	.....	.....	.....	.....	.....	.....
Wheeling	$ 65,000,000	.....	.....	.....	.....	.....	.....	.....	.....
Yorkville	.....	.....	.....	.....	.....	.....	48-in. 5-Stand tandem 1–Temper mill	Cleaning and pickle lines	.....
Steubenville	.....	270,000	Oxygen converters*	.....	.....	Rebuild hot strip, Pipemills	.....	.....	.....
Martins Ferry	.....	.....	.....	.....	.....	.....	.....	No. 2 Galvanizing line (C)	.....
Crucible	$ 5,000,000	.....	.....	.....	.....	.....	50-in. Sendzimir	.....	.....
Silicon Steels	$ 4,500,000	66,000	.....	.....	.....	.....	Single stand 4-high 2000-fpm reversing	1–Bright annealing	.....
Washington Steel	$ 2,600,000	.....	.....	.....	.....	.....	48-in. Sendzimir	.....	.....
Pittsburgh Steel									
Monessen	$ 15,000,000	211,000	.....	.....	.....	.....	.....	Coil annealing furnace (C)	1–19 Oven coke battery
Timken	$ 7,000,000	.....	.....	.....	.....	Tube mill improvement	.....	2–Annealing furnaces	1–Oxygen plant
McLouth	.....	100,000	.....	.....	.....	.....	50-in. Cold	.....	.....
Rotary	$ 4,500,000	.....	.....	.....	.....	15-Stand bar	.....	.....	.....
Colorado Fuel & Iron									
Wickwire-Spencer	.....	160,000	Enlarge O.H. from 110 to 170 tons	.....	.....	Rod mill	.....	.....	.....
Pueblo	.....	.....	Rebuild	.....	.....	.....	.....	.....	.....
Detroit	$ 10,000,000	160,000	.....	.....	.....	.....	.....	.....	.....
Alan Wood	$ 14,000,000	175,000	1–140-Ton O.H.	.....	.....	.....	1–4-Stand tandem (C) 1–Single stand, 2-high temper(C); 1–Single stand, 4-high temper	8–Batch annealing furnaces (C) 1–Annealing furnace 1–Slitting line (C)	.....
Atlantic Steel	$ 10,000,000	125,000	1–Electric furnace	.....	.....	21-Stand rod and bar mill	.....	Reheating furnace	.....
Connors Steel	$ 2,500,000	.....	1–Electric furnace	.....	.....	1–Merchant	1–Cold draw	.....	.....
Milton Steel	$ 1,000,000	.....	1–Electric furnace	.....	.....	Bar mill equipment	.....	.....	.....
Carpenter	$ 9,000,000	17,500	1–Electric furnace	.....	.....	.....	.....	.....	Forging press
Keystone	$ 10,000,000	.....	O.H. Imp.	.....	.....	.....	.....	.....	.....
Northwestern	.....	250,000	.....	.....	.....	1–16-in. Merchant	.....	.....	.....
Granite City	.....	360,000	O.H. Imp.	1–25-ft. Diam. blast furnace	.....	.....	.....	.....	.....
Copperweld									
Warren	$ 10,000,000	42,000	Electric furnace improvement	.....	.....	35-in., 2-High	.....	.....	Soaking pits
Glassport	$ 1,000,000	.....	.....	.....	.....	.....	.....	.....	Wire facilities
Shelby	$ 1,000,000	.....	.....	.....	.....	.....	.....	.....	Seamless tube equipment
Northeastern	$ 10,000,000	112,000	2–35-Ton electric	.....	.....	Merchant bar	.....	.....	.....
Eastern Stainless	.....	18,000	1–Electric (C)	.....	.....	.....	52-in. Sendzimir	.....	.....
Sharon Steel									
Sharon	.....	300,000	3–250-ton O.H.	.....	.....	44-in. Bloomer	.....	.....	.....
Detroit Tube	.....	.....	.....	.....	.....	.....	.....	Cont. strip annealing furnace	.....
Kaiser	$115,000,000*	.....	Oxygen* converter	.....	.....	.....	.....	.....	.....
Calstrip									
Los Angeles	$ 500,000	.....	.....	.....	.....	.....	Cold strip	Cont. anneal. furnace	.....
U.S. Pipe & Foundry	.....	.....	.....	1–Blast furnace	.....	.....	.....	.....	.....
Interlake Iron									
Chicago	$ 10,000,000	.....	.....	.....	.....	.....	.....	.....	1–50 Oven coke battery

Partial totals $10,360,500

*Unsubstantiated report $2,000,900,000

(C) Denotes completion in 1955.

FOREIGN PLANTS

In 1955, production of steel increased in practically every country of the world. Production set new records in practically every area, since most countries had expanded capacity. Steel production in the world totaled about 292,000,000 tons, compared with 245,000,000 tons in 1954.

Steel production in the more important steelmaking countries is estimated as follows with figures in net tons:

Country	1955	1954
Australia	2,400,000	2,117,000
Austria	1,900,000	1,822,000
Belgium	6,400,000	5,522,000
Brazil	1,200,000	1,288,000
Canada	4,410,000	3,192,000
France	13,700,000	11,319,000
West Germany	23,600,000	19,221,000
India	1,900,000	1,882,000
Italy	5,900,000	4,638,000
Japan	9,100,000	8,523,000
Luxembourg	3,500,000	3,118,000
Mexico	550,000	515,000
Netherlands	1,100,000	1,023,000
Saar	3,200,000	3,093,000
South Africa	1,700,000	1,523,000
Spain	1,400,000	1,209,000
Sweden	2,200,000	2,052,000
United Kingdom	22,100,000	20,742,000
United States	116,934,000	88,312,000
Yugoslavia	900,000	679,000
Total Free Nations	224,094,000	181,790,000
China	3,000,000	2,397,000
Czechoslovakia	5,500,000	4,884,000
East Germany	2,800,000	2,486,000
Hungary	1,600,000	1,644,000
Poland	4,450,000	.....
Rumania	900,000	693,000
U.S.S.R.	48,000,000	45,203,000
Total Iron Curtain	66,250,000	61,677,000
Other Countries	1,700,000	1,546,000
Grand World Totals	292,044,000	245,013,000

Plans for further expansion of steel capacity are common throughout the world. It is expected that steelmaking capacity throughout the world will total about 360,000,000 tons in 1960 compared to the present 300,000,000 tons. Of this increase, the free world is planning 35,000,000 tons, and an additional 24,000,000 tons will be developed behind the iron curtain. These figures include 12,000,000 tons in the Western Hemisphere of which 2,600,000 tons will be in Latin America. Western Europe, including the United Kingdom, is expected to add 16,400,000 tons, of which 9,300,000 tons will be in the six-nation European coal and steel community.

An announcement was made that a new pipe mill is being planned by Canadian Western Pipe Mills Ltd., following the completion of their first unit at Port Moody, B. C. Plans for the second mill indicate a range of sizes up to 16 in. in diameter. The initial mill has an annual capacity of more than 60,000 tons of black and galvanized pipe from ½ to 4½ in. diameter. Pipe is manufactured by the continuous cold-forming, resistance-weld process.

Construction also started on a fourth steel mill in western Canada during the year. This is the Premier Steel Mills, Ltd., located in Edmonton, Alberta, Canada. The main unit is a $2,000,000 merchant mill which was scheduled to go into production at the end of the year. Steel will be furnished by a 4700-kva arc melting unit built in England.

Early in the year, Dominion Foundries & Steel Ltd., announced an expansion program which will cost an estimated $12,000,000 for facilities for production of tinplate products, including a second continuous electrolytic tinning line, a cold strip shearing line and a new temper mill. Also under construction during the year were additional coke ovens next to their existing battery.

In December the company announced an additional $15,000,000 expansion program which will boost annual ingot capacity from 600,000 to 720,000 tons. A $25,000,000 program finished early in 1955 had doubled productive capacity to 600,000 tons per year.

Late in December The Steel Company of Canada announced a new $70,000,000 expansion program at its plant at Hamilton. Included in this program are a slabbing mill, a second electrolytic tinning line, temper and cold sheet mills, an ore bridge, extensions to the dock, and more annealing capacity. Construction will start early in 1956.

South of the border, the Altos Hornos de Mexico, S.A., has under construction an electrolytic tinning line and another open hearth furnace. Adjacent to this plant, a new company, the Mexicana de Coque y Derivados, S.A. de C.V., started this year. This is a 114-oven coke plant which will supply coke for the blast furnaces of Altos Hornos.

Mexico is protecting its domestic steel industry by limitations on imports, and plans gradual expansion of her steelmaking capacity. Under their program, present capacity of 825,000 tons should increase to 1,250,000 tons by 1960. No general blast furnace program is reported and Mexico will depend heavily on the United States for its scrap.

In South America a number of countries are expanding their steel facilities. At the present time Argentina is making plans for an annual capacity of 1,100,000 tons, including the present 235,000-ton industry. Unfortunately, most of the principal raw materials must be imported. With the fall of Peron, it is believed that foreign financing and supplies of equipment can be handled more easily than before.

Early in the year, before Peron's fall, the Export-Import Bank approved a loan for $100,000,000 for an Argentine steel plant. This was to be used to build up the $250,000,000 General Manuel N. Savio plant in Argentina. This plant is at San Nicolas, up the Parana River near Rosario. Annual capacity will be about 490,000 net tons of finished steel products, such as blooms and billets, rails and structurals, plates, hot and cold-rolled sheet and tinplate. The mill was to be owned by mixed government and private concern called the Sociedad Mixta Siderurgia Argentina (SMSA). Plans include the use of the $16,000,000 strip mill originally built for Czechoslovakia, and sold at auction to Argentina last year.

The contract for the first blast furnace (a 1300-gross ton unit) was placed with an American concern. This was scheduled for operation by March 1957. Two additional blast furnaces are planned for the future. The contract for the six 200-ton open hearth furnaces was to be placed in Europe. A battery of coke ovens was to come from

Germany. Rolling mills were to come from the United States.

Steelmaking capacity in Brazil, now 1,435,000 tons per year, is to be increased to about 2,500,000 tons by 1960. This program includes expansion of the Volta Redonda plant to 1,000,000 tons and two plants elsewhere in Brazil. Other privately-owned units are also to be expanded and their product mix diversified.

Brazil is also getting a new steel mill which will be located near the port of Santos. Capacity will be 210,000 tons annually. Production is scheduled in about three years. Financial arrangements had not been completed at the time of the report on this unit. The mill is to be located near the coastal ranges where the Cubatao refinery and the Cubatao hydroelectric plant are located. A new canal is to be dug to permit direct unloading of iron ore from Minas Gerias through the port of Victoria.

Colombia's new 165,000-ton integrated steel plant which was French-financed and built to American design made its first steel in December 1954. This plant is now seeking financial assistance to expand capacity and add additional products to the billets, shapes, bars, rails, reinforcing bars and wire it is now making.

The Venezuelan Government signed a $173,000,000 contract during the year with Fiat and Innocenti of Italy to construct a steel mill with an ultimate capacity of 421,000 tons yearly at the junction of the Caroni and Orinoco Rivers. Initially, three Simens-Martin furnaces of 175-ton capacity will be used for steelmaking. This job also includes a 40-42 in. blooming mill, two light structural and rail mills, and three mills for rolling reinforcing bars and wire rod.

Development of the Venezuela project is planned in two stages, one based on an annual production of 300,000 tons, the second on a yearly production of 421,000 tons. The most urgently needed products will be produced in the first stage, while the latter stage increases these items and adds other products such as hot and cold sheets, tinplate and galvanized sheets. All raw materials will come from Venezuelan sources. Construction was started in the fall of 1955 and production should start in 1958, with full production in 1959.

Peru is building a 65,000-ton all-electric integrated steel plant at Chimbote. This plant is French-financed and designed. It includes a two-unit electric pig iron plant, a steel melting shop, a combination breakdown billet and sheet bar mill, a combination bar and rod mill, and a hand hot-rolled sheet mill. The rolling mill, with imported billets, was to start operation in January 1956, and the iron and steel furnaces in May 1956.

In Great Britain the Iron and Steel Board reported to Parliament that they expect an increase in steel demands by 1958 for 25,200,000 net tons. Of this 21,800,000 tons will be for home consumption and 3,400,000 tons for export. To meet this increased demand, a number of schemes for additions have been established at an estimated cost of $800,000,000. The biggest increases are in South Wales and Monmouthshire, where capacity will go from 4,750,000 tons in 1954 to 5,800,000 tons in 1958. On the North-East coast, the increase will be from 4,100,000 tons to 5,110,000 tons. Lincolnshire and Yorkshire will increase from 1,730,000 tons to 2,530,000 tons.

The Steel Company of Wales will have the greatest individual increase with 1,135,000 tons. John Sommers Shotton Plant will increase in the same period by 732,000 tons, and Dorman Long will increase by 590,000 tons. These figures are, of course, primarily estimates and may vary as plans progress.

Only a small increase in scrap supplies is foreseen from 10,500,000 tons in 1954 to 11,900,000 tons in 1958. This will require additional pig iron output which should go from 13,400,000 net tons in 1954 to 17,000,000 tons in 1958. The largest increases will be in the same three plants as the increases in steelmaking capacity.

The report indicates that finished steel will become a larger percentage of production. Demand for sheet and tinplate is expected to rise from present 2,270,000 and 960,000 tons respectively to 2,960,000 and 1,620,000 tons respectively. Increase in tubemaking capacity should go up 1,240,000 tons to 1,680,000 tons. The program includes four-high plate mills to meet increased demand for wide thin plates.

Among the expansion programs completed in England last year is a new battery of 44 coke ovens which was put into operation at the Stanton Works of the Stanton Ironworks Co. This doubles their coking capacity and makes them independent of purchased coke.

A new 60-ton electric arc furnace is in operation in England at Samuel Fox & Company, a branch of the United Steel Companies, Ltd. Believed to be the largest electric arc unit in Europe, the furnace is a top-charge, direct-arc, tilting type with three 20-in. diameter carbon electrodes connected to a 15,000 kva transformer. Inside diameter of shell is 19 ft, and this is backed with an 18-in. thick refractory lining. Bottom refractory thickness is 27-in., and roof thickness is 14 in. An electric induction stirrer is to be installed on the furnace.

A new rod and bar mill is also to be constructed by Samuel Fox & Co. Ltd. Completion is scheduled in about two years. The mill will roll bars and rods in alloy, high carbon and stainless from 0.212 to 2.5 in. in diameter. Maximum speed of the mill is about 3,000 fpm, faster than any similar mill in the United Kingdom.

The mill consists of a three-stand, 18-in. roughing train, with the first two stands three-high and the third stand two-high, driven from one 1,500-hp motor. Following this is a 14-in., single stand, two-high mill driven by a 350-hp motor. Intermediate train consists of four 11-in., two-high stands arranged in pairs, and then there is an 11-14 in. cross-country mill consisting of four two-high stands, with individual 350-hp motors.

The continuous finishing train consists of a six-stand alternate vertical and horizontal 10-in. mill, driven by a 250-hp motor to each stand, which will roll at speeds over 3,000 fpm.

Late in November, construction started at Ravenscraig for the Colvilles Company on a program including a new blast furnace rated at 390,000 net tons of pig iron annually, two batteries of 35 ovens each to carbonize 11,200 tons of coal a week, and a new steelmaking shop to produce 450,000 tons a year. Completion of this program is scheduled for 1957. A 6-ft wide sintering plant will also be installed.

The blast furnace will have a hearth diameter of 25 ft-9 in. It will be operated at 5 to 10 psi top pressure. The melt shop will have 200-ton open hearth furnaces.

The European Coal and Steel Community is engaged in a two-part program, expanding and balancing pig iron, steelmaking and finishing capacity, while lowering

unit production costs. The problems of each member country and the programs undertaken vary. For example, in West Germany the emphasis is toward plant modernization, the building of larger furnaces, and construction of two modern continuous strip mills. In France, efforts are being made to beneficiate and coke Lorraine coals. In Belgium and Luxembourg, efforts are concentrated on improving efficiency of operations while scrapping older mills and furnaces. Italy is still deficient in blast and steel furnace capacity and plans to build more of both. The Netherlands have completed their current expansion program.

It is estimated that the member nations of the European Steel & Coal Community will produce an estimated 79,000,000 net tons in 1955. However, even this did not satisfy the demands of Western European industry and imports were heavy from other countries.

The West German steel industry set new production records during the year, and West Germany's steel industry passed that of Great Britian to take second place in Europe behind Soviet Russia.

A modernization program is contemplated which will raise the combined steel capacity of France and the Saar to 18,000,000 tons a year. Of this the schedule in France raises steel capacity at a rate of 550,000 tons each year until 1960.

In Belgium, a merger was accomplished during the year between John Cockerill, Ougree-Marihaye and Ferblatil. This concentrates about 45 per cent of Belgium's steel capacity in one company. This is typical of the large-scale steel mergers common on the continent, and it is believed that more than 50 per cent of the steel capacity in the European steel community will be concentrated in firms which can produce at least 1,500,000 tons of steel annually. Usinor and Sollac mergers which took place several years ago are examples of the trend. Other more recent are the combination of Phoenix and Rheinische Rohrenwerke. In Luxembourg, steel production is concentrated in three firms.

There are about 55 steel companies in West Germany of which 27 are fair-sized concerns. Seventeen were in the pre-war Vereinigte Stahlwerke. However, this cartel was broken up after the war.

Extensive expansion plans are also under way in Germany. By 1965, steel capacity is expected to go to 27,500,000 tons from the present 23,600,000 tons. The Klockner Steel Company, the second largest in Germany, plans to build a 2,000,000-ton integrated plant in Bremen. The company plans to buy a continuous, 54-in. cold strip mill for this unit in the United States.

In Germany, five new blast furnaces were put into operation between the first of the year and September.

Steel capacity is being increased in Spain, and it will be up to 1,500,000 tons in 1956, 1,800,000 tons in 1957 and 2,100,000 tons in 1958. A new fully integrated plant will be constructed at Aviles by the government. Equipment for this plant will include a reversing hot strip mill bought from McLouth Steel Corp., a blooming mill, an oxygen plant, a continuous pickling line, stack annealing furnaces and a shear and cutting line. There will be two blast furnaces in this plant; one has been ordered from Great Britain and the other from the United States.

Norway's first integrated steel mill was completed during the year at Mo-i-Rana. This mill is now scheduled to produce 170,000 tons of rolled products annually. Plans call for eventual expansion to 240,000 tons per year. The company is operated by the state-owned operating company called Norsk Jernverk A/S. Pig iron is made with electricity from taconite concentrates and the steel is made in electric-arc furnaces.

At the Karabuk Works in Turkey plans are under way for expansion of the open hearth plant to bring capacity up to 400,000 tons of ingots per year. The program also includes a continuous bar, rod and skelp mill, foundries and fabricating shop. A 34-in., 2-high reversing slabbing and blooming mill was put into operation in this plant during the year.

One advantage which foreign countries have in steelmaking is the low wage rate. The average minimum wage rate in European countries in 1953 was 30 cents an hour. The highest in Europe was in the United Kingdom with 41 cents an hour.

At the end of 1955 Poland came to the end of its six-year plan for industrialization (1950-1955). A 5-year plan is being set up for further expansion through 1960. As a result of this development, steel production in Poland in 1955 of 4,450,000 tons was over three times the production in 1938. In the coming 5-year plan, which starts in 1956, a goal of 7,000,000 tons of steelmaking capacity has been set.

In the last 10 years Poland has built 27 new open hearths and six electric furnaces. A new hot sheet rolling mill has just been put into operation at Nowa-Huta at Krakow in southern Poland. This mill has an annual capacity of 700,000 tons which will go up to 1,200,000 tons when all installations are in full operation. Tinning and galvanizing facilities are also being installed.

Steelmaking production in Russia was around 48,000,000 tons in 1955. Plans indicate that a target of 60,000,000 tons by 1960 will be met.

From the reports of several delegations which have visited Russia's steel plants, there are indications that very impressive records are being made. Practice is apparently modern by most standards. As an example, at the blast furnace plant at Zaporajhe, there are five 26-ft diameter furnaces operating at 5 psi top pressure. The furnaces are not similar and production from them varies from 1,000 to 1,750 tons per day. Plants are also working towards a 100 per cent sinter burden.

In the steelmaking division of this plant, an unusual feature is that the open hearths are fired with a mixed blast furnace and coke oven gas with enriched air with up to 25 per cent oxygen. The roofs of the furnace are of the chrome-magnesite type with a large rise. It is reported that they have little trouble with roofs under this hot flame. This plant has a battery of ten 225-net ton furnaces.

Expansion programs are wide spread throughout Asia and the Far East. In 1955 steel production in China was almost 3,000,000 tons and pig iron production was even greater. Efforts are being made to expand production further. Nationalist China (Taiwan) has a program to produce an annual 40,000 tons of pig iron, 77,000 tons of steel and 66,000 tons of rolled products.

By the end of 1955 Japan should have a capacity of 5,500,000 tons of rolled steel, and 5,000,000 tons of pig iron.

Extensive development work is going on in the Philippines. Their program has three stages and by the

end of the third stage, capacity will be 132,000 tons of electric pig iron, and 560,000 tons of electric furnace steel annually. Products will be plate, billets and sheets.

The National Shipyards and Steel Corporation of Iligan City in the Philippines started operations on a new rolling mill in 1955. The mill will produce bars, structural shapes and angles.

The Government Planning Commission for India's first 5-year plan had a target for annual steel production of 1,848,000 tons by 1957-58. As of May, the annual capacity of India was 2,200,000 tons of pig iron and 1,800,000 tons of steel ingots. Existing plans will increase output by 550,000 tons of finished steel.

In a second 5-year plan which is already set up, ingot production is to reach 6,720,000 tons by 1962, with new plants in ten more new locations in different parts of the country. A third 5-year plan is also under discussion which should produce 11,000,000 tons by 1967.

In their plans, there are three new million-ton plants. One of these is covered by an agreement signed during the year with Russia. Final price was to be set nine months after a detailed project report is to be written, a report which India can reject. This plant rated at 1,100,000 tons is scheduled to go into production by December 1958. It is located in Madhya Pradesh.

During the year the Government of India also reached a new agreement with Krupps-Demag to revamp the state-owned Hindustan steel project at Rourkela, Orissa. This new agreement contemplates expanding the installed capacity to 1,200,000 tons of ingots from the original design of 500,000 tons. Finished product is to be sheet, strip and plate. Completion of this is to be October 1958. Plans indicate that about 750,000 tons of ingot capacity is to be made by the oxygen-blown converter process and the balance of 250,000 tons is to be made in open-hearth furnaces.

In November an agreement was signed between the Kaiser Engineers and the Tata Iron & Steel Company, Ltd., for a $130,000,000 steel plant expansion at Jamshedpur, India. This project is one of the largest steel plant construction jobs ever awarded an American firm and it will increase India's current steel capacity about 45 per cent and will raise Tata's plant production from 1,460,000 to 2,240,000 net ingot tons annually. The job will require the purchase of about $50,000,000 dollars worth of machinery and equipment, and is scheduled to be completed in 30 months.

This project will provide new integrated facilities from raw materials handling through finished steel. Additional coking facilities include a new 26-oven battery of coke ovens and a by-product plant. Other facilities include a sintering plant with a capacity of 4,000 tons per day; a 28-ft diameter blast furnace, additional open hearth furnaces, a 46-in. blooming mill, a medium and light structural mill and a continuous sheet bar mill.

RAW MATERIALS

In spite of the continuing demand for high production in all phases of industry, the need for raw materials was ably met, and few serious delays were due to lack of supplies.

As far as the steel industry was concerned, the shortages were confined primarily to nickel and copper, with the shortage in copper being reflected in much higher prices. Copper ended the year with a price of about 46¢ to 47¢ per lb, more than 50 per cent higher than the price at the beginning of the year. The price increases were largely a result of increased demand and shortages of supplies due to bad strikes throughout the copper mining industry.

Ore — The foresight of the steelmaker was rewarded when he met this record year with sufficient ore. The work which has been done in past years on the development of new ore supplies and on upgrading ores as mined started to pay off. Total ore used was 141,000,000 net tons.

Shipments of iron ore down the Great Lakes ended with a 43 per cent gain over 1954. A total of 87,459,853 gross tons made this the fourth highest total on record. In 1954 about 60,000,000 tons were moved, and the record year, 1953, was about 96,000,000 tons. One factor in the reduction of ore shipments down the lakes in spite of record steelmaking is the larger quantity of imported ore used this year.

Foreign ores went up because a number of the new foreign developments went into full operation. The Labrador development was estimated to ship about 6,000,000 tons during the year. Steep Rock Iron Mines shipped 2,265,000 tons. Inland Steel is also carrying out extensive dredging operations to open up its leases in the Steep Rock area. Other developments in Chile, Peru and Liberia also went into high gear.

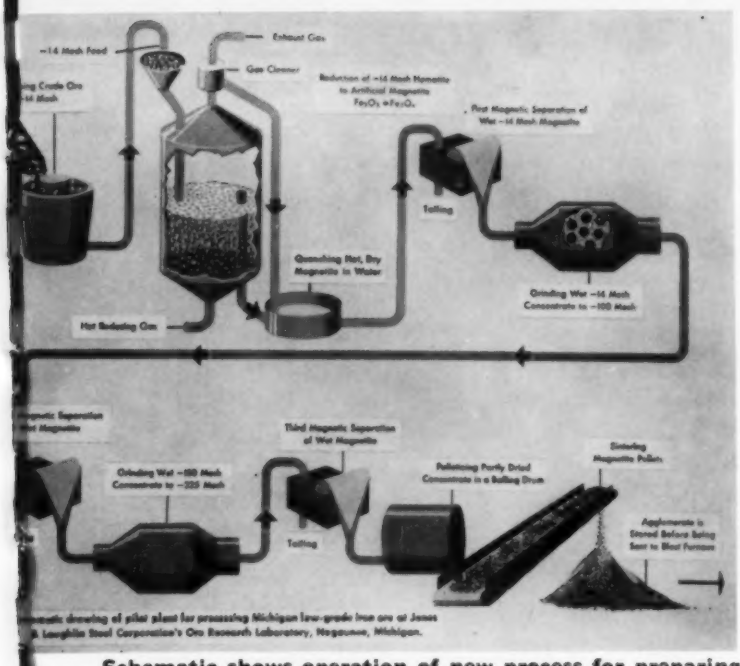
The largest single iron ore cargo ever to arrive in the United States was discharged at Baltimore in August. The cargo totaled 30,373 long tons of high grade ore from Venezuela. This ore was destined for plants at Sharon and Pittsburgh. The vessel carrying this cargo is one of three sister ships rated at 60,000 tons, but limitations in the harbor facilities in Venezuela limit the amount of ore which can be taken on boats.

In February 1955, iron ore prices were increased 20¢ a ton, an unusually small increase. Ore prices are now about $10 a ton. From all indications, ore prices will go up. Price increases of 50c to $1.00 per ton are expected for 1956, due to higher operating and transportation costs. Some of the increase reflects the additional work which must now be done to prepare ore for shipment.

A special United Nations Committee which has been working on world's iron ore reserves estimated that they total 93,000,000,000 net tons. Present operations should last 600 years. Of this supply, India is estimated to have one-fourth, or 23,000,000,000 tons; Brazil is next with 17,600,000,000 tons, and the United States is credited with 6,600,000,000 tons. France has almost 7,700,000,000 tons and Communist China, 4,400,000,000 net tons. An estimate of 3,300,000,000 tons for European Russia is included. These figures are for ores with more than 35 per cent iron.

The U.S. Bureau of Mines has estimated that there are over 4,400,000,000 net tons of ore in the United States of over 50 per cent iron content; over 2,200,000,000 tons with from 35 to 50 per cent, and 67,000,000,000 tons with an iron content of 25 to 35 per cent.

In the West, an addition to the Kaiser iron ore mining facilities at Eagle Mountain will raise the shipping grades iron content from the present 55 to over 60 per cent. The new plant will have two separate systems for concentrating the ore. One of them will handle the


−14 Mesh Feed
Exhaust Gas
Gas Cleaner
Tailing
Quenching Hot, Dry Magnetite in Water
Grinding Wet −14 Mesh Concentrate to −100 Mesh
Hot Reducing Gas
Third Magnetic Separation of Wet Magnetite
Grinding Wet −100 Mesh Concentrate to −325 Mesh
Tailing
Pelletizing Partly Dried Concentrate in a Balling Drum
Sintering Magnetite Pellets
Agglomerate is Stored Before Being Sent to Blast Furnace

Schematic shows operation of new process for preparing ore concentrates from taconite.

magnetic ore (half the ore in Eagle Mountain is magnetic), and the other will handle the non-magnetic ore in the material rejected from the first processor.

Bethlehem Steel Company developed an ore source in Marmora, Ont., Canada, capable of shipping 500,000 tons of concentrate. This is a low grade magnetite which is beneficiated by magnetic concentration.

Pickands-Mather & Company and the Steel Company of Canada are combining efforts in a $16,000,000 iron ore project 40 miles north of Quebec. Reserves are sufficient to sustain a 600,000-ton annual production for the next 15 to 20 years of 66 per cent high grade concentrate.

During the year it was reported that a contract was negotiated with Canadian Javelin Ltd. and a group of German steel companies under which a benefication plant will be built at some mines in Newfoundland. Initial shipment of this ore is scheduled for the spring of 1957 and the contract calls for the purchase of up to 3,000,000 tons of ore a year on a long term basis.

Drilling exploration is under way on what may be a very large deposit of ore in Bolivia. The location is in Mutun, close to the Paraguay river. Tests indicate an iron content of 50 to 55 per cent.

An interesting step in ore preparation was developed by Jones & Laughlin. Most of the taconite processes are using magnetic ores because of their relative ease of separation after crushing. Jones & Laughlin Steel Corporation have set up a process by which non-magnetic hematite is transformed into artificial magnetite. Their plans call for a full scale commercial plant capable of delivering high-grade concentrate to their blast furnaces.

This system uses a fluidized solids reactor. Nonmagnetic taconite, ground fine, is reduced to magnetite while suspended in a stream of hot reducing gas. Turbulence is used to maintain uniform reaction and intimate gas content. The hot ore leaving the furnace is quenched in water, which cracks the ore and helps further fine grinding. Then follow three stages of grinding and magnetic separation, the ore being concentrated to a 63 per cent iron content.

After the completion of the concentration, thickening tanks and drum filters are used to extract the water by means of vacuum pumps. The concentrate is fine and must be pelletized.

Operations started in October at the huge E. W. Davis Works of Reserve Mining Co. This plant, which was described last year, will have an annual capacity of 3,375,000 long tons of iron ore pellets which will go to Republic and Armco, the joint owners of the $190,000,000 project. Major construction work still to be completed is in the concentrating building where grinding, magnetic separation and filtering take place, and in the pelletizing plant. The initial operation was in the first section of the twelve-section plant. Completion of the remaining sections was scheduled for February 1956.

Taconite concentrate produced in 1955 exceeded 1,000,000 tons. Production in 1956 is expected to be about 4,000,000 tons.

Scrap — The increased demand for steel increased the demand for scrap and, as a result prices increased throughout the year from $35 a ton in January to over $50 in December. Supplies were apparently ample, although there was agitation to limit or eliminate the exports to foreign countries. This is now authorized on an open-license basis, and totalled 4,835,000 net tons in 1955.

The use of scrap briquettes designed specifically for open-hearth use is being promoted by two companies who are preparing this material. Advantages of this material is that it has a density of 75 to 80 per cent, higher than most of the scrap used at the present time. The difficulty is to obtain carloads of turnings of uniform analysis to make the briquettes. One company in the Pittsburgh district is charging about 1000 tons a month and reports results which compare favorably with No. 1 heavy melting scrap.

Coal — Coal, a sick industry for some years, is due for a revival. The Interior Department estimates that there will be a steady rise in coal output over the next 10 years.

Ferroalloys — A new producer of ferroalloys went into production this year at a plant near Beverly, Ohio. The plant started the first of four electric melting furnaces, and was scheduled for completion by the end of the year. Capacity of the unit is about 4 per cent of the requirements of the country.

Manganese — A new record of 300,000 net tons for production of high grade manganese ore in the United States was attained during the year. This compares with 211,000 tons in 1954. This is still small in comparison with the 2,000,000 tons used.

The Emergency Procurement Service, a division of General Services Administration, is carrying out a number of studies on the development of low grade manganese ores. Most likely sources of usable ore are now considered to be open hearth slags, the Aroostook county ores, and the manganiferous low grade iron ores from the Cuyuna iron range in Minnesota. These materials all have widely different characteristics and may require different processes.

The Venezuelan Ministry of Mines announced that huge manganese deposits have been discovered east of Upata, Venezuela. Estimated quantity is said to be

several million tons with a content of 28 to 55 per cent pure metal.

Nickel — Nickel, which was the last major metal to be decontrolled, may become the first one to be controlled again. This is one of the materials in short supply, primarily because of the stock piling program on top of current demands. Free world production in 1955 was 427,000,000 lb compared with 387,000,000 lb in 1954. Production in 1956 should increase to 442,000,000 lb. Price in 1955 was constant at 65.4¢.

Zinc — Consumption of zinc in 1955 totaled about 1,100,000 tons compared with a previous record of 986,000 tons set two years ago. The increase in production helped satisfy the increasing demands of galvanizing lines.

Aluminum — For the fourth year in a row, the United States aluminum industry established new production records. Primary aluminum production in 1955 was over 3,100,000,000 lb, about 7 per cent over 1954. There were two price increases during the year to meet wage increases and advances in the cost of raw materials. The base price of primary aluminum at the end of the year was 22.5 cents.

There was substantial expansion in fabricating plant capacity. New fabricating equipment now includes sheet rolling mills up to 100 inches in width and foil mills up to 72 inches wide.

All three of the major aluminum producers announced expansion plans. Present and projected capacity of the aluminum industry runs about as follows:

	Present capacity, lb	Projected capacity, lb
Alcoa	1,400,000,000	1,585,000,000
Reynolds	830,000,000	1,100,000,000
Kaiser	816,000,000	1,308,000,000
Anaconda	120,000,000	120,000,000
Olin-Mathieson	.....	120,000,000
Harvey	.....	108,000,000
Total	3,166,000,000	4,341,000,000

Kaiser Aluminum & Chemical Corporation in December announced a new $280,000,000 expansion program which would bring that company's primary aluminum capacity to 1,308,000,000 lb, up more than 50 per cent. This will make this company the nation's second largest aluminum producer by a substantial margin. In this program, major projects are a 440,000,000-lb aluminum reduction plant at Ravenswood, W. Va., at a cost of $120,000,000 and a 1,000,000,000-lb alumina plant on the Mississippi River near Gramercy, Louisiana at a cost of $60,000,000. Construction starts in April 1956.

Kaiser is already building at Ravenswood a $96,000,000 sheet and foil rolling mill with a capacity of 33,500,000 lb, which will start operating by the middle of 1956. The Ravenswood reduction plant, with a 440,000,000-lb rating capacity will be the largest in the United States and will have 7 pot lines which will be completed by July 1957.

The company went ahead with this program because surveys indicate that aluminum usage will increase from 1955's estimated consumption of 4,000,000,000 lb to about 8,000,000,000 lb by 1965.

Other items in the program include two extrusion plants and an enlargement of the company's rod, bar, wire and electrical conductor plant at Newark, and expansion in aluminum forging capacity.

Alcoa's output of primary aluminum in 1955 was about 1,400,000,000 lb. Alcoa's installed capacity will reach 1,585,000,000 lb in 1956 with the completion of the expansion projects at Point Comfort and Rockdale, Texas, and at Wenatchee and Vancouver, Washington. Alcoa reports that building construction displaced the transportation field as the biggest market for the aluminum industry.

Increasing demand for foil will be met by Alcoa by an increase in their foil production capacity by 32,000,000 lb in 1956. Additions will be at Davenport, Iowa and Alcoa, Tenn. Additions in 1955 were made at Alcoa and Edgewater, N. J.

Reynolds Metals Company will increase its primary aluminum capacity to 1,100,000,000 lb. The increase consists primarily of a 270,000,000-lb expansion of primary producing and related facilities, including new mines in Haiti and Jamaica.

Additions to present plants will provide 70,000,000 lb of new primary capacity and are scheduled for completion in 1956. This consists of 50,000,000 lb of additional capacity at the company's Alabama plant and 20,000,000 lb at the Texas plant which was started in August. The remaining 200,000,000 lb of primary production capacity will be in a new plant in the Ohio River Valley. This plant will utilize a 300,000-kw power plant which will use coal from company-owned mines.

The Anaconda Company opened its $65,000,000 plant for production of aluminum at Columbia Falls, Montana on August 15. Planned capacity is 120,000,000 lb for January 1, 1956. The plant is so laid out that this capacity can be doubled. Two pot lines will be in operation at this plant.

The Harvey Machine Company started construction on its new $65,000,000 plant at The Dalles, Oregon in September. This plant will add 108,000,000 lb to primary capacity.

The Olin-Mathieson Chemical Corp. set up plans to build an aluminum plant of 120,000,000 lb capacity on the Ohio river. A number of sites are being studied. Construction is to start in the spring 1956 with completion scheduled for 1958. This job is being done with Pittsburgh Consolidation Coal Company, which is also involved in a similar plan with the St. Joseph Lead Company for a plant in the same area.

As an example of the switchover from copper to aluminum, the Western Electric Company announced during the year that, because of high copper prices and shortages, they were setting up an engineering development program to investigate the substitution of aluminum for copper in telephone cables.

Titanium — In September the ODM suspended its program of government assistance to add titanium sponge capacity, although it will review capacity constantly. Sponge production in 1955 was about 8,000 tons compared with 5,370 tons in 1954 and this should go up to 22,500 by 1957. However, capacity to produce this metal has apparently increased faster than the military can use it. At the present time, the following companies are producing titanium sponge: DuPont, Titanium Metals Corporation, Cramet, Dow Chemical Company, and Union Carbide & Carbon Corp.

Three new plants started deliveries during the year. These came from the new 7500-ton Electro-Metallurgical plant at Ashtabula, the 1800-ton plant of Dow Chemical Company, and the 6,000-ton Cramet Inc. plant at Chattanooga, Tenn. These plants will come into full operation in 1956. The price of titanium sponge dropped from $4.50 at the beginning of the year down to $3.45 by the end of the year. Other products had corresponding price reductions.

Mallory-Sharon Titanium Corporation completed a new melting plant in Niles, Ohio, which increases titanium ingot capacity to 3,000,000 lb per year. The new plant has four double melting furnaces. It combined consumable electrode double melting and new vacuum melting techniques.

Construction of the first titanium sponge plant in the United States which will use the sodium reduction process is proceeding at the Electro-Metallurgical Co. plant at Ashtabula, Ohio. In the process, titanium tetrachloride will be reduced with sodium.

The largest single factor which has affected the processing of titanium is its tendency to absorb hydrogen from both gaseous atmospheres and chemical cleaning baths. All processing steps have to be carefully examined to minimize the hydrogen content of the finished product.

New deposits of titanium were found during the year in Norway, New York State and Florida.

Copper — Early in the year four large U. S. mining companies announced plans for joint development of one of the largest copper ore reserves in the world in southern Peru. This deposit is estimated to have about 1,000,000,000 tons of copper ore with a 1 per cent metal content.

The Anaconda Company discovered a new property in Chile, the Indio Muerto Mine, which promises to rank among the great copper mines of the world. The company also reported the discovery of a new ore body at their Butte, Montana properties. It may develop into a major low-grade open pit copper mine. World copper production in 1955 totaled 2,700,000 tons, with about 45 per cent mined in the United States. Prices varied from about 30 to 50¢ per lb during the year.

COKE OVENS AND BLAST FURNACES

The demand for steel and pig iron increased the demand for coke, and as a result, a number of beehive coke ovens were put back into operation. In November, U. S. Steel announced it would rehabilitate 500 ovens. Pittsburgh Consolidation Coal was also reactivating 300 old ovens, and Hillman Coal & Coke doubled their active beehives in Fayette County. Some of the beehive coke is also going to Europe. These beehive units now constitute the country's only practical reserve of coke-making capacity.

Youngstown Sheet & Tube Company put into operation a new 76-oven coke oven battery at the Campbell Works in Youngstown in September. This unit has a daily capacity of 1250 tons of coke or 450,000 tons a year. The ovens feature underjet firing, and have 730 cu ft of capacity. They are 43 ft-2⅜ in. long, 13 ft-2⅜ in. high and average 18 in. in width with a 3 in. taper. The new ovens are on the site of the old No. 1 battery.

A new battery of 75 coke ovens are to be constructed at the Indiana Harbor Works of Youngstown Sheet & Tube Company. This battery, scheduled to be in operation by September 1956, will be the fourth at the Harbor plant. It will have underjet combination ovens, and will have a capacity of about 1250 tons of coke daily.

Inland Steel Company ordered a new battery of 87 coke ovens as part of their multi-million dollar construction program at the Indiana Harbor Works. This will be the seventh battery at the plant and will raise annual capacity from 2,143,400 tons to 2,598,000 tons of coke.

In August, the Wisconsin Steel Works ordered a 52-oven coke battery for South Chicago. These ovens will have a rated capacity of 290,000 tons per year and may be underfired with coke oven gas or blast furnace gas.

Interlake Iron Corporation started work in the second quarter on a new battery of coke ovens at their Chicago plant. Project involves an expenditure of $10,000,000 and is scheduled for completion in the summer of 1956.

U. S. Steel's program for rebuilding the Clairton Works took a big step with the completion of No. 1, 2 and 3 coke batteries which increased the total to 17 batteries rebuilt of the 23 at this plant. In addition to these three batteries with 192 ovens, another contract for the design and construction of three batteries totaling 192 new ovens was awarded in November.

The newly completed coke battery at the Lorain Works of National Tube went into production in September. This is a 59-oven battery with a daily capacity of 760 tons of coke. Another battery is scheduled for construction.

American Steel & Wire Division at Cleveland made great efforts to reduce smoke from their new coke plant. Even though the four batteries of 180 ovens were rebuilt, the main factor in air pollution was the charging cycle. This problem was overcome through the use of two special larry cars which divert the combustion products into a special recovery system through special sleeves fitted tightly over the covers during charging. A steam jet aspirator in the ascension pipe sets up a vacuum which pulls fumes into collector mains. All four hoppers of the larry car are connected into the aspirator system. Several other divisions of U. S. Steel are using this development.

Colorado Fuel & Iron Corp. succeeded in changing over its coke plant for large scale production of diammonium phosphate for fertilizer. CF & I is the first major coke oven operator to make this move. This material will take the place of ammonium sulphate, which is the conventional by-product of the coke oven operation. The changeover required only minor changes in production facilities. Instead of removing the ammonia from the coke oven gas by scrubbing through sulphuric acid, CF & I substituted a phosphoric acid.

One of the requirements in the control is that the bath must be kept within a fairly narrow pH range, slightly on the acid side. In the case of ammonium sulphate, factors such as acidity, specific gravity and bath temperatures can vary widely.

A company in Pittsburgh acquired patent rights and processes of a German firm which has long been in the coke oven and accessory equipment business. The coke oven design used by this firm differs basically from

those used in this country because of the firing method. The ovens are heated with fresh fuel alternately from the bottom, and then the top of the oven. It is claimed that this gives more uniform heating with less fuel consumption, and better quality coke and increased by-products.

A German development introduced into this country removes the ammonia, hydrogen sulphide and hydrogen cyanide from coke oven gas by washing them with waste pickle liquor. In the process, pure ammonium sulphate crystals, ferrous hydroxide and iron cyanides are recovered in a form which can be marketed, and hydrogen sulphide is processed to simple sulphur or sulphuric acid which can be sold or used. The pickle liquor used is the typical solution of ferrous sulphate which contains some free sulphuric acid. Equipment for the process is relatively simple.

A specially-designed system for the recovery of light oil from coke oven gas, recently installed at the Midland plant of Crucible Steel, has increased recovery more than 10 per cent even though only one of the two existing absorption towers was used. Conventional towers already existing could not handle all of the gas produced because of excessive pressure drop. A new scrubbing system gives the desired intensity of contact by circulating the oil at high velocity with pumps. A simple, highly effective mist separation section prevents carry-over of liquid wash oil in the gas.

A new process has been introduced from Germany for producing super-refined benzene, toluene and xylene from light oil. This process reduces the thiophene content (a harmful sulphur compound) to less than one part per million and by subsequent removal of the paraffins, a solidification point of 5.40C may be easily obtained.

During the process, certain impurities in the light oil fractions are removed by hydrogenation. The vaporized light oil and coke oven gas are passed over a catalyst where impurities are converted into easily removed compounds. Further purification for the removal of paraffinic compounds is accomplished by distillation techniques. The installation of this equipment is easily accomplished and eliminates the need for acid washing of the light oil fractions.

Construction costs are being held down by maximum usage of material handling facilities. Under construction here are some of the ovens for the new 64-oven coke batteries at U. S. Steel's Clairton works.

Blast furnace expansion was a quiet issue during the year. About the only unit which reached the active authorization stage is one by Granite City Steel, which was authorized in November. This will replace a unit constructed in 1921. The new furnace will have a hearth diameter of 26 ft-6 in. and will be lined down to 25 ft-0 inches. Estimated capacity will be about 1200 tons per day, double that of the existing furnace.

The stack of the new furnace will be built in an area adjacent to the old furnace. When it is completed, it will be rolled into position immediately after the old stack has been torn down. This method has been used only three times previously in the United States. Existing foundations of the old furnace will be used for the new unit. Construction is expected to be completed next fall.

The world's largest blast furnace was blown in on June 5th at Great Lakes Steel Corp., Detroit. This unit has a hearth diameter of 30 ft-3 in. Other pertinent dimensions are: diameter of bosh 33 ft-3 in.; height from iron notch to top ring 110 ft-0 in.; total height 252 ft above the yard level; working volume, 55,300 cu ft. Rated capacity of unit is 50,000 tons of iron per month.

An American company was awarded the contract for the design, engineering and procurement of a large blast furnace to be built in Spain. This unit is to be constructed for the Empresa Nacional Siderurgica, S.A., a government company at Aviles, Spain, in a new integrated steel plant which is to be built. The unit will have a 28-ft hearth, and would have a capacity of 1500 tons of pig iron per day with U.S. practice. Construction is expected to be completed by the end of 1956.

Republic Steel Corporation converted its No. 2 blast furnace at Youngstown to high pressure blowing last February, thus making it the third of the five Youngstown furnaces to be so equipped, and the ninth in the company.

Chemical cleaning of blast furnace mains has been done without stopping transmission of gas, resulting in large economies. As an example of what can be done, the method was used on gas mains at a plant which had 50 ft of 60-in. crossover line and 130 feet of 84-in. gas main. These lines were filled with deposits to within 18 inches of the top. Jet nozzles were inserted through special valves welded in the top of the lines. A manifold outlet was used and four nozzles were operated at one time. Chemical solvents were circulated and allowed to soak for a definite time and then drained to complete the cleaning. The method saved the steel plant operator from buying 40,000 gallons of fuel oil per day during the cleaning period, since the gas was not cut off.

Split wind blowing with topping turboblowers is done at the National Works of the National Tube Division. This gives blower operation for blast furnaces with only about one-third of the Btu required by a modern condensing steam turboblower operation. Secondly, it provides a method of utilizing the full capacity of the blowers with the added safety of two blower operation on the furnace.

The Association of Iron & Steel Engineers completed their research program at Columbia University on the heat transfer through blast furnace hearths this year. Several conclusions have resulted from this work. One of these is that the best *thermal* use of carbon is made

if it is placed on the outside rather than on the inside of the furnace, which has also been found true in actual practice.

Studies also showed that underhearth cooling will result in a relatively small change of depth of penetration near the sides of the furnace where a breakout may occur. It will result, however, in large changes at the center. Thus, underhearth cooling should result in smaller salamanders but does not give an appreciable increase of safety against lateral breakthrough.

An improved blast furnace plate holder was put on the market during the year. The plate can be removed from outside the furnace simply by removing water connections and flange bolts. The cooling plate holder is gas and water tight. Only one size holder is used in all blast furnaces.

More even distribution in charging blast furnaces is offered by a new top or bell arrangement in which a vertical cylinder or skirt guides the stock so it forms a concentric ring between the periphery of the shaft and the center. This development has been expanded so that the distribution system can charge more or less of the larger or smaller particles in practically any horizontal ring at the stock line as desired by the operator.

It was reported that Duquesne Works of U. S. Steel tried the use of large quantities of open hearth slag in the blast furnace, with worthwhile results. No adverse effect on analyses or quality of finished steel were experienced. The slag charge was about 450 lb per ton, which may not be suitable for many plants but at Duquesne had a number of advantages:

1. Recovery of metallic scrap as well as metallics in the oxides that were in the open-hearth slag.
2. Limestone burden was reduced about 325 lb to 825 lb per ton of iron.
3. Manganese loss to slag is now recirculated and results in a substantial reduction in the ferromanganese addition.

The use of open hearth slag has generally been undesirable since the hot metal would usually have a relatively high phosphorous content which in turn would hinder open hearth operation.

One helpful factor was that the plant standardized on an open hearth charge of 57 per cent hot metal, 33 per cent scrap, 3 per cent cold iron, and 7 per cent ore. This charge is conducive to a fast full-flushing practice and eliminates 50 per cent of the total phosphorous in the bath.

Information derived from the sinter burden test at the Gary works indicates that it is not necessary to provide a long period of adjustment when going to a high percentage of sinter in the burden. There was little change in the temperature of the iron, but high blast temperatures were needed for smooth operation. When volumes were lower, there was a tendency to get a build up on the walls which required periodic cleaning. On the other hand, there was a lower coke rate, lower flue dust production and a definite increase in iron production. The furnace on which the test was run has a 25-ft hearth and was chosen for the test because the lines were known to be intact.

At the Bethlehem plant of Bethlehem Steel, practice during the year on the blast furnaces has been to use from 60 to 70 per cent sinter.

Further reports on low shaft blast furnace research in England indicate that the low shaft furnace has been successful in producing Thomas low silicon pig iron. Such pig iron was produced from raw materials which could not be used in conventional blast furnaces. Low temperature coke was an excellent fuel. Heat losses in the shaft are rather low and correspond to about 7 per cent of the heat input. On the other hand, indirect reduction of ore by the gases is not as effective as in the conventional blast furnace. Tests indicate that a total of about 1200 kilograms of carbon is required per metric ton of pig iron, or an efficiency of about 30 per cent. This is an increase in fuel requirements of 25 per cent compared with the blast furnace. The CO content and heating value of the gas obtained, however, are relatively higher. It is now believed that oxygen enrichment may be necessary.

A development for processing fine raw materials is the Lubatti electric furnace used in Italy. The furnace consists of a flat hearth with one tap hole for metal and another for slag. The top of the furnace is open, this enables positioning of the electrodes both horizontally and vertically. The burden, which is a fine ore, is fed continuously onto the slag so that a layer from 6 to 8 inches thick floats on the surface of the liquid slag. The ore is then reduced in this layer and the energy for the reduction is taken from the slag bath which has a temperature of about 2700 to 2880 F. Since the burden is fine, the carbon monoxide which is generated and passes through helps in the reduction. The final gas which escapes has more than twice as much carbon dioxide as carbon monoxide.

One of the reasons why blast furnace capacity is not being increased through the authorization of new units is because high sinter practice will give additional pig iron production in existing units. It has been estimated that some 20 per cent additional capacity can be obtained without building a single new unit. This development means that the industry will place emphasis on the construction of sintering plants, and a number of such projects are being planned. At the beginning of 1955 sinter plant capacity totaled about 32,000,000 tons.

Some of the new sinter plants under construction include a 4,000-ton unit for Fairless, an 8-ft wide, 2,500-ton per day unit for Weirton, an 8-ft-3 in. wide unit for International Nickel's Copper Cliff Plant to be used for iron recovery, two 6-ft wide machines at Sparrows Point Plant at Bethlehem (which will make a total of four at that plant), and another unit for Kaiser's Fontana works. United States Steel Corporation also announced plans to build a $25,000,000 sintering plant at Houseville, Pa., to serve the Pittsburgh area plants. It is understood similar plans are under way for the Chicago district.

The new sintering plant at Weirton Steel Company replaces one which has been in operation since 1926.

National Steel announced at the end of the year that they will build additional sintering plants at Great Lakes Steel and Weirton plus extensive ore and sintering handling systems. Both units will be 12 ft wide, a new record and unit at Weirton will have a capacity of 6,000 tons a day while that at Great Lakes will produce 7,000 tons a day.

A flue dust recovery system also under construction at Weirton will clarify the blast furnace gas-washer water now being discharged into the Ohio River. The

flue dust sludge which is recovered for this operation will be used in the sinter plant operation.

Armco Steel Corporation contracted for a sintering plant and ore bedding system at the Houston, Texas, Works of the Sheffield Steel Division. This sintering unit, designed to produce 1400 net tons of sinter per day, will be 6 ft wide x 89 ft long. The bedding system, the fourth of its type in the U. S., will provide a means of blending the three types of ores now used at the Sheffield blast furnaces.

The new sintering machine at the Steel Company of Canada has a capacity of 1700 net tons per day. This machine of the continuous strand type has an effective suction area of 647 sq ft over 16 wind boxes, and 79 individual pallets, each 6 ft-6 in. wide by 3 ft-3⅜ in. long. There is no mechanical connection between the pallets, each being moved along the strand by the pushing action of the following pallets.

Studies on the production of sinter, show that one of the most satisfactory ways to increase the production rate is to increase the bed permeability. If the sinter mix has a large amount of fines, better permeability can be obtained by secondary mixing in a drum similar to that used for pelletizing. By the addition of the right amount of water, small seed pellets are produced from the finer materials, and the coarser constituents are relatively unaffected. Thus, higher permeability is obtained and only a small amount of dust passes through the grates of the sintering machine.

Another idea for producing pellets is a pelletizing disc or pan which rotates on a tilted axis. Powdered materials are fed to the pan and sprayed with water as in the pelletizing drum. The action of the rotating disc classifies material and produces segregation of the pellets with the larger pellets rolling towards the rim and the smaller ones staying near the center, or under the larger ones. As the disc becomes filled, only the larger pellets are discharged over the rim.

A dust collector consisting of six cyclone type units arranged in a large V with three cyclones to each leg was installed at a large sintering plant. Operators report savings of up to $1500 a month including some $700 worth of sinter a month. The balance of the saving is attributed to reduced operational and maintenance costs. An efficiency of 92.5 per cent is claimed.

STEELMAKING

Perhaps the outstanding development in steelmaking was that experience with the oxygen-blown converters in operation at Dominion Steel and McLouth showed the process to be a practical method of making steel. About 1,700,000 tons of such steel were made in 1955. At the end of the year several other companies announced that they would adopt the method for expanding their steelmaking capacity. Among companies planning to install oxygen-blown converters is Jones & Laughlin Steel Corporation. Two units are scheduled for Aliquippa where ample supplies of hot metal make the process particularly attractive. Also, it has been reported that Wheeling Steel Corporation will install oxygen-blown converter facilities. Studies are also being made on combining the process with the hot blast cupola instead of the blast furnace.

The application of these units is reversing the trend of recent years of the decline of the bessemer process. In the bessemer process, only small quantities of scrap can be utilized, resulting in higher costs of metallics per ton of steel. With oxygen-blown units, scrap contents up to 30 per cent can be used. The big factor is that the introduction of nitrogen gases in the steel is also eliminated, giving a quality steel comparable with open hearth grades.

Furthermore, an advantage of the process, when steel expansion is being considered, is that the invested capital, including the oxygen-generating plant, is reported to be about half that needed for a modern open hearth plant of the same capacity.

One of the limitations of the process is that it may not be practical for making steel with a carbon content of over 0.35 per cent. On the other hand, with the aid of a secondary processing such as an electric furnace, it is believed that the steel may compete with open hearth and electric steels throughout the full range of specifications.

As an example of the economics of oxygen steelmaking, it is reported that an oxygen shop that turns out 450,000 tons a year could be built for under $10,000,000, including two 35-ton vessels with one operating and one stand-by, and all the operating equipment, utilities, storage facilities and air pollution control equipment. A 525,000-ton open hearth shop using 275-ton furnaces would cost about $21,000,000. With large shops, the cost differential is reported to be greater. The materials used in the oxygen converter will cost about $1 per ton more at the most than in the open hearth. However, savings in labor and maintenance of about $3 a ton offset this cost.

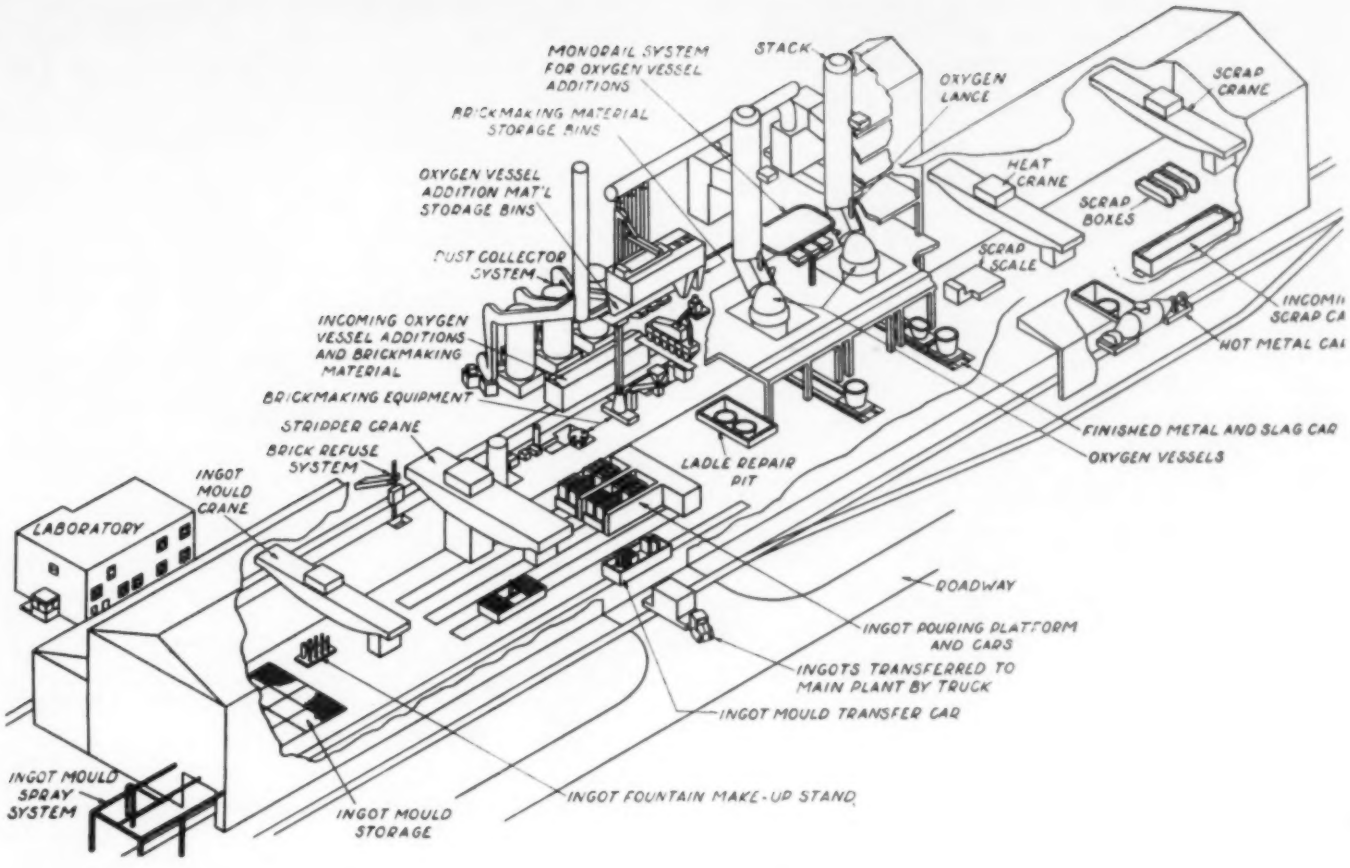
Both concentric and eccentric type converter vessels are used. Refractory linings are about 20 in. thick. At first, lining life was about 120 heats. However, this has been extended to about 400 heats per lining through the use of a burned magnesite brick for the inner lining. Vessels are operated for about 10 days before relining. The average yield is about 89 per cent.

With 20 to 22 minute blowing periods and complete tap-to-tap cycles of 35 to 40 minutes, a 40-ton vessel will produce 50 to 60 tons per hour and the oxygen used would be about 2,000 cu ft per ton of steel. One of the advantages of the oxygen steel is that cold working properties seem better than those of open-hearth steel, making it especially suitable for cold drawn wire and cold rolled strip and sheets.

In some analyses a typical content would be about 0.0020 per cent nitrogen, 0.013 per cent phosphorous and 0.020 per cent sulphur.

Operating procedure at Dominion and McLouth vary in a number of details. At McLouth there are three 40-ton vessels which are set in pits, with the trunnions at ground level. Hot metal from the blast furnace comes into one end of the melt shop in a bottle car. The amount of iron needed for heat is poured into a charging ladle in the pit, and this in turn is put in the pouring car which carries it along the track to the vessel. The scrap is added to the ladle. The ladle car then tips the charge directly into the furnace. A flux car is used for charging the stone.

The pouring practice from the converter vessel is different from the usual bessemer operation. In the side of the converter, opposite the charging side, a hole is



Schematic sketch shows flow through oxygen steel plant department at Dominion Foundries and Steel Plant, Ltd.

provided for pouring. After blowing the heat, most of the slag is poured off through the mouth of the converter to the slag pot on the charging side of the vessel. The vessel is then turned to the opposite side and steel runs out the pouring hole into the teeming ladle. After the steel is out, the remaining slag is emptied through the vessel mouth into a slag pot.

McLouth is not satisfied with the refractory linings and are considering installing equipment to make refractory materials.

It was found necessary, however, to provide for an efficient gas cleaning system. This consists of a length of duct from the converter to the gas cleaning system. Above the converter, the duct consists of a water-cooled section lined with refractories. Below the water-cooled section is an annular pipe drilled with holes at intervals to permit water to be ejected into the gases. A two-pass sparkbox is located at the upper end of the hood, where water sprays cool the gas down to 500 F. A tower-type washer and a disintegrator complete the cleaning. The gas entering the atmosphere appears to be a cloud of steam.

At McLouth, electric furnaces were installed with the idea that the converter would be used for initial refining, with final finishing to be done in the electrics. When this procedure is used, it has been found that it takes only 350 kwhr to finish the steel.

Dominion Foundries & Steel Company of Hamilton, Ontario were the first to use the process and use its steel for tin mill products, plate, sheet and strip. They report that the steel is the best deep drawing steel they have ever had. Dominion's 40-ton converter is used entirely for the production of 100 per cent rimmed mild steel with carbon content under 0.10 per cent.

Dominion's equipment for cleaning the gases consists of a brick-lined water-cooled hood which takes the fumes and depends upon excess air to keep the temperature of the gas below 1500 F. The gases then go through water spray cleaners which exhaust the gases to the atmosphere at less than 140 F.

The plant uses bottom pouring on cars. Two cast iron pouring bases 12-ft square are set side by side on each car, and 16 ingots at a time can be poured from one down-fountain. As much as 45 tons can be poured on one car. The Dominion unit averages a little over 45 tons of metallic charge and has operated with as much as 50 tons of metallic charge. After the first three months of operation, 250 heats were being obtained per lining and it is expected to eventually obtain a life of about 300 heats. The refractory for the working lining is made by Dominion. Steel production at this plant is limited by the hot metal available. The amount of scrap in the charge is dependent on the silicon in the hot metal, and varies from about 17 per cent with 0.50 per cent silicon to 34 per cent with 2 per cent silicon.

One of the weaknesses of the conventional bessemer converter is analytical control. In a new German procedure, a radiation pyrometer is mounted on a long pivoted probe which can be lowered over the mouth of the converter and moved out of the way as the converter is tilted. This pyrometer gives readings which check within a few degrees those of the immersion pyrometer.

In addition, a spectroscopic technique is also used for continuous observation of the converter flame and for

obtaining a continuous recording of its condition. By splitting the light from the converter flame, a continuous record is obtained of the ratio of the intensity of the red light to the intensity of the violet light. Variations in flame radiation are correlated with variations in temperature throughout the course of the blow.

Another method which offers promise for increasing steel production at a relatively low capital cost is the use of desiliconized wash metal. This procedure was presented at an AISE meeting during the year. It is primarily based on theoretical study and calculations which in turn are based on a number of laboratory tests. In the procedure, hot metal from the blast furnace is desiliconized with oxygen before being charged into the open hearth. Assuming metal with 4 percent carbon, one per cent silicon and one per cent manganese, it takes about 60 lb of oxygen per ton of metal to reduce the silicon content to below 0.20 per cent. Carbon goes down to about 3 per cent. This will also raise the hot metal temperature to about 2950 F.

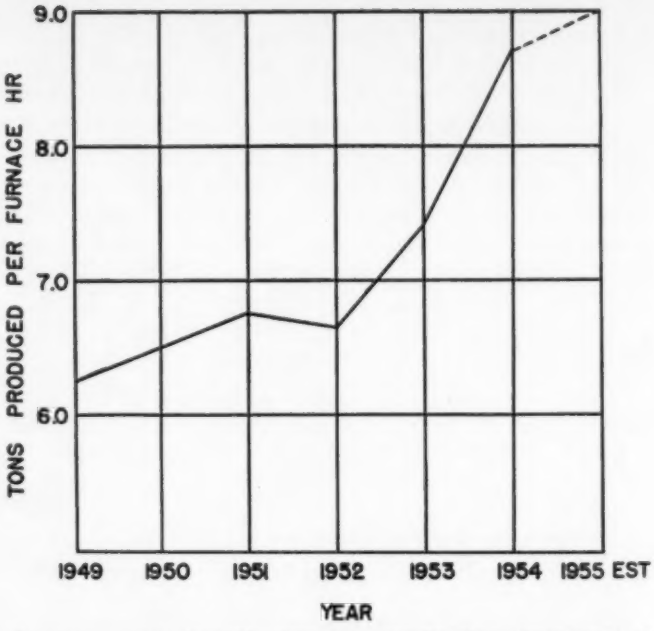
Normally, hot metal cannot be charged into the open hearth until the furnace temperature is about 2750 F. Desiliconized metal, however, since its temperature is 2950 F instead of the ordinary 2450 F, can be added to furnace heats much sooner. Then, because of the higher melt-down temperature, the ordinary oxidizing and refining reactions are accelerated. The desiliconized metal tends to refine more rapidly, and it also adds extra heat to the charge above the critical temperature resulting in savings in both fuel and furnace time. Estimated increases in production which can be obtained range from 25 per cent with 50 per cent wash metal to a 50 per cent increase with 70 per cent wash metal. Another advantage is that the steel plant can become fairly independent of outside scrap sources, since home scrap would make up more than 80 per cent of the cold scrap needed in the charge mix. Test work for this project was carried out in induction furnaces.

The investment cost for the *additional* capacity which would be obtained is estimated at about $7.50 per ingot ton, compared with $30 to $40 per ton for new open-hearth installations. This estimate is based on a cost of $3,000,000 for desiliconizing equipment in an open hearth shop to raise capacity from 1,000,000 to 1,400,000 tons of steel ingots.

Similar results are claimed for electric furnace plants where hot metal is available. A feature here is that the method may offer a practical way of using hot metal in the electric furnace.

Prerefining of pig iron outside the blast furnace is also being tried in England. In the desiliconization operation there, 30-ton transfer ladles are used into which 20 tons of hot metal from an inactive mixer are poured on limestone and fluorspar. While the ladle is being filled, further limestone is added and oxygen is blown through a lance into each ladle for 20 minutes at 250 cfm. The slag is then skimmed off and the metal taken to the open hearth furnace. The hot metal now has the silicon reduced about half and is about 200 F hotter than the unblown metal. This has resulted in increased output from the steel furnace. It is reported also that a plant in West Germany desiliconizes about 80,000 tons per month of pig iron for use in basic converters with a 35 per cent oxygen blast.

However, the old work horse of steelmaking, the open hearth is improving its efficiency, making it harder



Average open hearth furnace production increase of about 45 per cent in the last five years in this cold metal shop is an example of how the steel industry is increasing efficiency. Hourly tonnage would be greater in larger units.

for some of the new processes to compete. In the open hearth, attention to small details is important in increasing production. As an example of what can be accomplished, the open hearth plant of Bethlehem Pacific Coast Steel in San Francisco increased the average tons per hour rate in its cold metal shop by 45 per cent. This shop has five 75-ton furnaces with an annual capacity of 300,000 tons.

The increase in production was obtained through higher heat input made possible by a redesigned burner and changing the furnace throat area, by changing the reversal time (which also reduced brick consumption and overheating), by an increase in slag pocket volume, by a change in some of the refractories and by setting up a more efficient set of standards and operating procedures. As one example of this last item, a 25 per cent reduction in charging time was attained with a corresponding 20 per cent reduction in total heat time. Other details included setting up a standard flux burden for each type of steel. This flux burden is kept at a minimum in order to obtain more rapid heat transfer through the thinner slag cover.

At Inland Steel Company's No. 2 open hearth shop, steel quality and steel operations have improved since the use of oxygen was begun. In 1954 this shop used 1,200,000,000 cu ft of oxygen. Some of the advantages were faster melt-down, fewer long refining periods, more flexibility in the use of scrap, and improved fuel. Fuel input had been increased from 60,000,000 Btu per hour to 90,000,000 Btu per hour. Another advantage is that the faster scrap melt-down reduces the amount of sulphur absorption from the fuel.

On an overall basis, Inland Steel credits about 250,000 tons of its additional steel capacity directly to the use of oxygen in open hearth melting practice. In 1954 the plant used about 180 tons of oxygen daily for flame enrichment and for decarbonization.

Weirton Steel Corp. ordered a 600-ton open hearth furnace as part of their expansion program. This is said to be the largest ever to be built. It will be about 100

ft long and its size will necessitate the use of two slag car openings on the furnace.

Some operators are still experimenting with the all-basic open hearth furnace. One reports that he has obtained as much as a 20 per cent gain in steelmaking capacity compared with conventional silica brick. In addition, fuel consumption has been cut 5 per cent below the requirement of the conventional open hearth. Although basic brick cost about four times as much as silica brick, thicknesses of roof and walls may be reduced.

Keystone Steel & Wire are very enthusiastic about their all-basic open-hearth furnace. This 175-ton cold metal unit at the Peoria, Ill., plant is producing better than 19 tons per hour, some 10 per cent higher than the other furnaces. Keystone reports a saving of one hour in tap-to-tap time, and it is believed that, over a campaign, savings in manhours will more than pay for the higher cost of the brick. The furnace attained a total of 503 heats in its first campaign.

At Algoma Steel, an attempt was made to increase firing rates in the open hearth to obtain higher productivity. Unfortunately, checker replacement had been running high on furnaces in the No. 2 shop, being about 15 per cent at 300 heats and 40 per cent at 600 heats. The use of basic capped checkers, however, resulted in no dust adherence and slagging on the basic checkers below the top course, even after 700 heats. Flues remained open without blowing for the entire campaign. Finally, basic checkers were found to be economical on a straight replacement comparison with clay.

One company increased ingot production by a new method for rebuilding open hearth furnaces. A completely new furnace was fabricated on the floor of the open hearth shop and then rolled into place. This resulted in a substantial saving of time compared with the usual method of rebuilding a furnace in place. Operating results with the new design have been favorable.

The use of a multi-purpose excavater with a telescopic boom is cutting down repair and rebuilding time in open hearth shops. The unit enables removal of hot brick within 45 minutes after the furnace roof has been dropped by putting the telescopic boom into the furnace. This compares with the usual three hours, and the machine can save about six hours per furnace.

Shot-holes are being made in slag pockets of open hearth furnaces by powder-lancing. It is possible to make six shot-holes in the slag pocket of a 250-ton furnace in about six hours by this method, in comparison with about 24 hours required to mechanically drill the same holes. A powder dispenser furnishes the correct amount of metallic powder to the lance to assure smooth and uninterrupted operation.

A great deal of work has been done in the Los Angeles area on air pollution control and it is reported that of the 41 steelmaking furnaces in operation there, all but ten have such equipment. Electrical precipitators, bag houses and water scrubbers are all used. Operation with electrical precipitators has shown that water spray towers may be necessary to lower gas temperatures and increase the moisture content of the gases before they enter the precipitators.

Kaiser Steel reports that the electrical precipitator installed on their No. 9 open hearth stack now removes more than 95 per cent of the entrained particles. This is their second stack to be equipped for smoke control. Engineering is under way for installation of smoke control devices on the next four stacks, and before the end of 1956, the program for installing electrostatic precipitators on all nine open hearth stacks will be completed. By this time, it is estimated that the expenditure for this program will be over $8,000,000. The second unit is 50 per cent larger than the first one on No. 3 open hearth.

One research man reported that experiments on moving filters of slag wool together with rotating screw agglomerator units have shown great promise in reducing air pollution by open hearth gases. Further studies should develop units of practical size and cost.

In last year's report, much discussion was centered on the future of electric steel. At the present time, there is the rash of orders for new electric steelmaking units. One company reports it has received more orders for top-charge electric steelmaking furnaces than ever before, having on their books 15 furnaces with an annual capacity of 2,500,000 tons of carbon steel. These units are going to Pittsburgh; Houston, Texas; Kansas City, Mo.; Chicago; and Warren, Ohio. Some of these are new units and some are replacements. Orders cover three 24-ft diameter units, three 22-ft units, two 20-ft units and others down to 11 ft.

Atlantic Steel Company reported that in 1954 their electric furnace practice gave an average heat size of 76.4 tons and produced 135,000 tons of ingots in 8,135 operating hours. Electrical consumption averaged 500.3 kwhr per net ton, and electrode consumption was 9½ lb per ton of ingots. Yield was 91.4 per cent.

Application of current control to electric arc furnaces has resulted in production increases of up to 70 per cent. Harmful voltage dips are eliminated by transformer design with impedance between the windings somewhat higher than normal. This gives a 3.25 per cent negative value for the equivalent reactance of the high voltage windings which corrects line drop within these limits. Then automatic optimum current control is used on taps 5, 4 and 3 of the furnace transformers. Taps 2 and 1 are manually controlled by the operator. The use of the optimum settings calls attention to transformer temperatures. Each furnace transformer is equipped with three hot spot indicators.

Steel hub form reduces time needed to install electric furnace rammed hearths.

Other significant electrical improvements include better tap changer leads between transformer terminals and tap changer terminals, rubber sealed secondaries, and pressure relief valves on main tanks and on tap changer compartments.

In electric furnace maintenance, the use of a steel hub form for ramming hearths has taken the work out of the job. Ramming is done in back of the form, giving greater uniformity and density to the banks. In the procedure, the bottom flat is first rammed into place. The steel hub form is then centered on the flat and 2 x 6 in. boards are fitted to it in spoke-like fashion. The ends of the boards are cut at the angle required for the bank slope. A facing of 1 x 6 in. boards are tacked on the ends to make up the form. Ramming mix is shoveled into the space between the form and the brickwork and compacted by vertical ramming up to the top of the facing boards. In one case, the hearth of a 20-ton furnace was installed in 6¾ hr, using nine tons of ramming mix.

In another plant, maintenance of electric furnace bottoms has been lessened through the use of a 96 per cent MgO ramming mix. Shrinkage is less than 1 per cent and it is claimed that the material does not have to be sintered, since it forms a ceramic bond at 1500 F, which eliminates long burning-in time and increases production. Drilled holes in the shell are used to eliminate moisture.

Enriched iron ore concentrates also offer possibilities as a source of metallics for the electric furnace. Some operators claim that such iron pellets are superior to steel scrap for the electric furnace. The manufacture of pellets is practical since one company has found a way of removing oxygen from the concentrate used to make the pellets by passing the powdered ore through a vertical furnace where heated hydrogen combines with the oxygen and passes off as steam.

Vacuum melting will provide better steels than available before. Unit shown will produce 1000-lb ingots, although some now in production will produce ingots up to 5000 lb.

Another development in special steelmaking practice is the increased use of vacuum melting. A number of companies have announced production facilities for such practice. Total vacuum melting annual capacity is now 3,500 tons and this should double by the end of 1956. Allegheny Ludlum has a capacity of 125 tons of metal per month which can be increased about four times very quickly.

Allegheny Ludlum uses the consumable electrode process. This requires electrodes which are cast from a production size electric furnace air melt. A water-cooled copper crucible is used. The bottom of the electrode and the top of the ingot mold are kept under vacuum. The material is deposited from the electrode into the mold and the impurities are volatilized and withdrawn by a vacuum pump. It is reported that 5,000-lb ingots up to 20-in. diameter are being made. Properties are being obtained which cannot be obtained with conventional procedures. An important one is low gas content since the gas bubbles which form in the molten metals around the arc are pulled out by the vacuum. Homogeneity and workability are better, soundness gives better yield, and mechanical properties are also higher.

A new vacuum melting furnace, put into operation at the end of the year by Vacuum Metals Corporation at Syracuse, N. Y., has a capacity up to 2200 lb. With this size, the making of metals in vacuum furnaces is going out of the pilot plant stage and starting an era of commercial operation. Ingots of 2,000 lb weight can be cast, making possible the use of this material for much larger engine components. Annual capacity of this unit will run from 600 to 900 tons.

Another vacuum application is being imported into this country from Germany. This process eliminates the hydrogen which is of particular trouble in forging ingots. Degassing is carried out in large low-pressure vessels which operate with ladles of special design. There are three methods used: (1) the material is degassed by teeming the contents of a ladle into a second ladle in an evacuated chamber; (2) the ingots are degassed while pouring into an ingot mold in the evacuated chamber; and (3) ladle degassing is used, followed by casting in ordinary atmosphere.

Automatic pouring units are being accepted by the steel industry. As of the middle of the summer, 41 open hearth shops were using the new equipment and 13 of these were fully equipped. Several units have been shipped abroad. These units consist of a hydraulic cylinder mounted on the ladle stopper rigging, and an electro-hydraulic power unit mounted on the crane. By means of open and close buttons, a workman remotely located from the actual pouring operation can control the flow of hot metal from the ladle. Another result from the use of this equipment is increased safety to personnel.

A new exothermic hot top has been introduced which will give sounder ingots and reduce losses to a minimum with metal savings up to 10 per cent. It is claimed that the new material can be used as a lining for conventional clay or cast iron hot tops. The lining mixture consists of aluminum chips or powder plus some other chemical compounds which are capable of releasing free oxygen which in turn oxidizes with the aluminum. This material

ignites at 450 F, and an exothermic reaction occurs. The heated refractory which is produced has a very high insulating value. One of the advantages of this particular hot top is that it produces no metal through the exothermic reaction, and thus no contaminants are released to the ingot.

In the field of continuous casting, there are a number of processes under development but no new commercial one appeared during the year. Much experimental work is going on in Germany and in England. Increased output in commercial application is in general being obtained through the use of multi-strand operation rather than by increasing casting speed, and several twin and 4-strand machines have been built. In general, the processes apply to fully killed steels, although some work has been done on rimming steel where speed must be reduced to permit escape of gases.

In a German process, a stationary mold is used in which a continuous oil film is introduced into the mold wall above the metal level. It is reported that a twin-strand machine with a ladle capacity of 7 tons has been in commercial operation for several years. This produces about 300 tons a month in a wide range of structural, alloy, stainless and other steels. The normal range of sizes is from 4 to 6 in. squares or rounds, and slabs up to 18 in. wide. This system has also been combined in some Austrian plants with the reciprocating mold.

A continuous casting machine has been used to make strip in pilot plant quantities of high quality steel, aluminum, magnesium and brass down to ¼ in. Material is cast between two moving belts. It is said that the upper limit on speed is practically unlimited and thicknesses down to ⅛ or to 1/16 in. are believed to be possible. It is also claimed that the strip has very little segregation, if any.

ROLLING

Inasmuch as many of the hot strip mills in operation are now getting fairly old, up to 20 years or more, some need modernization and revamping. In so doing, attempts are being made to increase capacity also. As an example of this, the strip mill at Lackawanna, originally built to produce 50,000 tons per month, has been modernized to get more than 200,000 net tons per month. Much of this increase has come from increasing slab thickness from about 4½ to 7½ in. Hot rolled coils have gone from about 250 lb per in. of width to about 450.

Weirton Steel Co. completed its rebuilding of the 54-in. hot strip mill and the first slab was rolled on August 16. Construction took nine months. The mill has a rated capacity of 225,000 tons per month or 2,700,000 tons per year. Delivery speed is 2,400 fpm. The mill now has three slab-heating furnaces and five stands in the roughing train, replacing four furnaces and four roughing stands used in the old mill. The roughing train can handle slabs 26 ft long, 48 in. wide and 7½ in. thick with a 30,000 lb maximum weight. The first three roughing stands are 44-in. diameter, two-high. No. 4 and 5 stands are four-high with 35-in. work rolls and 49-in. backup rolls. The slab heating furnaces are rated 200 tons per hour each. The new finishing train consists of six stands of 26¼ and 49 x 54-in. rolls. The two old basket-type coilers were replaced with

The new reversing cold mill at Newport Steel Corp., a 4-high unit which will roll at strip speeds up to 1700 fpm, started production last January.

three new mandrel-type coilers at the end of the runout table. The old hot mill turnover tables were removed. New hydraulic pumps can furnish water pressures up to 1200 psi.

The new tinplate mill at Weirton is expected to supersede the Fairless cold mill as the fastest mill in the world. Rated speed of the new unit is 7020 fpm compared with 6980 for the Fairless. The connected horsepower is 28,000 compared with 21,650 on the Fairless mill, due in part to the strip width of 48 in. compared with 44 in. at Fairless. The mill will handle coils up to 60,000 lb. Tonnage from the new mill should be substantially higher than any existing unit. Operation should start in the spring of 1956.

A hot strip mill now under construction has a number of novel features. One of these is speed matching of the table and feed rolls with the universal roughing mill, resulting in reduced slipping of the rolls under the slab. In addition, the control is so set up that the speed of the entry table and feed rolls is reduced by a percentage which corresponds with the reduction being made in the mill. The control is also so arranged that the reduction in speed feature transfers from one set of table and speed rolls to the other automatically with each reversal of the mill.

Another feature is automatic transferring of the table from speed matching with the universal roughing mill to speed matching with the finishing mill. This was done because the rolling schedule of the mill is such that the overall length of the mill could be reduced if one table were used as a roughing mill delivery table on the longer passes and then as a finishing mill entry table while the roughing mill is making the early passes on the next slab. The control is arranged to make this transfer automatically through a photoelectric control setup. Photoelectric units are also used to automatically turn the finishing mill descaling sprays on and off.

Newport Steel dedicated a new reversing cold mill last January which was a major item in their $9,000,000 expansion program. The new mill can roll strip at speeds up to 1775 fpm, in coil widths for shearing up to 48 in. wide. Rolls are 18 and 49 in. x 56 in. The mill can handle coils up to 40,000 lb with an inside diameter of 24 in. and outside diameter of 65 in. The mill is designed to reduce hot rolled, pickled strip from 0.080/

0.130 in. to finish gages of 0.015/0.050 in. The main drive motor is rated at 3000 hp, 150/375 rpm, 600 volts. Reel drive motor is rated 1000 hp, 300/900 rpm.

A number of mills have been experimenting with substitutes for palm oil in cold rolling. At one plant, tests on the use of a modified tallow gave results indicating that power consumption was somewhat less than with palm oil, even though the tallow was cut 6 to 1 with water rather than 3 to 1 as is common with palm oil. Tests were carried over a range of finish sizes. As part of the research done by the American Iron & Steel Institute, wire drawing setups were used to determine the relative lubricity of a number of lubricants. These tests indicate that palm oil and modified tallow give the best lubricity.

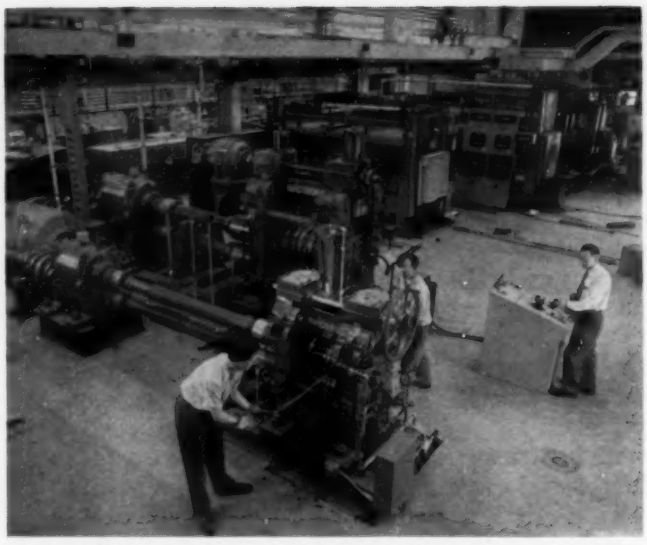
The new plant at Atlas Steels, Ltd. contains a number of unusual developments. In addition to the continuous casting process, the plant has an automatic scarfing machine, a hot planetary mill and an electrolytic salt descaling unit which is integral with their annealing and pickling line. The automatic scarfing machine operates successfully on stainless steels through the design of a slotted nozzle opening in which the powder nozzle has round tubes which lead the powder against flat impingement discs of tungsten carbide. This unit has an indicated savings of about 1.2 manhours per ton, and removes about 3½ per cent metal. All slabs are shot-blasted after scarfing and, if necessary, spot grinding is then used.

Steel for the hot planetary mill is heated in a high-head furnace about 75 ft long. Slabs enter cold and go through the furnace at about 6 to 10 fpm. Slabs run up to 34 ft long, up to 19½ in. wide and are about 2½ in. thick.

The main weakness which had to be overcome in the initial operation of the mill was the bearings on the work rolls. Cooling water originally got into these bearings, corroding them and causing seizure. This has been overcome by forcing oil through the bearings after shutdown and increasing the amount of lubrication during operation. It has been found necessary to have the feed rolls hot to make quality steel and control tracking. The feed rolls have been redesigned into a sleeve design with water-cooling for the bearings on the shafts. It has also been found necessary to keep tension on the mill to prevent buckling after the strip leaves the mill.

Reports on hot rolling on the planetary mill at Ductile Steels, Ltd., England, indicate that good results can be obtained from the process. It is essential that descaling be very thorough, since attached scale may be forced into the surface and will not be removed during the rolling. Care must also be taken that the speeds of the cage, works rolls and back-up rolls and the speed of the material are carefully synchronized. Top and bottom work roll assemblies must also be closely synchronized. This means that one work roll on the top and one on the bottom assembly have to pass through a vertical line through the bite simultaneously. When this is not done lines may appear across the strip.

Republic Steel Corp. installed a new 48-in. wide Sendzimir mill at their Massillon plant. This is the tenth such mill to be installed in the United States ex-



Several rolling mills were put into operation during the year in laboratories. This laboratory mill features a reversing rectifier drive controlled by a magnetic amplifier system.

clusively for the cold reduction of stainless steel. The new unit operates at speeds up to 713 fpm, and has an annual capacity of 25,000 tons. Republic also installed a new 26-in. two-high temper mill for stainless, a 54-in. intermediate anneal and pickle line, a 42-in. intermediate anneal and pickle line, a 15-in. single strand cut-up line, and a shot-blast cleaner for the No. 4 annealing and pickle line.

A $5,000,000 addition to the aluminum rolling equipment at Alcoa's Davenport works was announced last January. This consisted of a 100-in. cold mill for finish rolling wide aluminum coiled sheet and a 100-in. wide automatic shearing line.

In June, a new $20,000,000 expansion program at Davenport was established to satisfy a need for extra-wide sheets and plates in aluminum. This project includes a 160-in. hot sheet rolling mill, believed to be the widest hot mill designed for aluminum.

An investigation on the rolling of steel plate indicates that finishing temperature during the last working pass in the mill has a very important effect on final plate properties. Higher finishing temperatures produce steels having larger grains and lower yield strengths for the same tensile strength. A low transition temperature is desirable because it gives steel a better chance to resist brittle failure. On the average, decreasing the finishing temperature 100 F was found to lower the transition temperature 6 F by the charpy impact test and 8 F in the tear test. Influence of finishing temperatures was about the same for semi-killed steels as it was for aluminum-killed steels. Normalizing commercially rolled plate at 1650 F lowered the charpy and tear test transition temperatures of the steels investigated.

The Association of Iron and Steel Engineers completed a research project during the year which was set up to see what factors caused failures in hot strip mill work rolls and what can be done to get longer life from such rolls. This job was carried on in cooperation with the Roll Manufacturers Institute and the Carnegie Institute of Technology. The program consisted of experimental work on models, tests in mills, analytical

computations and measurements of rolls in the mill.

For the first time, tensile tests were obtained from material which had been used in actual rolls. The hardness and brittleness of iron work rolls make it difficult and expensive to machine specimens from rolls.

Other tests made in this program were the result of a development by one of the steel companies of a thermocouple which will measure the temperature of rolls while the mill is actually rolling steel. Data has been obtained on roll temperature during operation. This is particularly important since some of the greatest stresses in rolls occur because of temperature gradients within the rolls themselves. These are often sufficient to cause roll failure.

Another aspect of the work which is important is the measurement of actual internal stresses already present in the roll even prior to insertion of the roll in the mill. Under certain conditions, these may be the cause of premature failures.

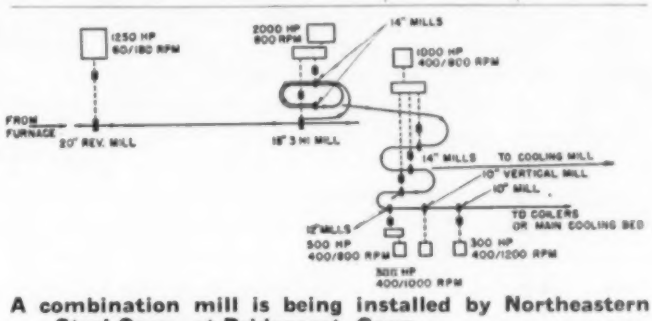
An entirely new drive principle is being advocated for mill drives. This arrangement consists of a combination of a differential gear with a variable speed hydraulic unit for each stand, with all stands driven by a common line shaft from the main motor. The basic idea behind this combination is to limit the speed range of each stand unit to actual requirements, and thus impose only partial loads on the variable speed units. This results in considerably less speed drop on full load, even to the point where the mill will behave practically as a solidly geared mill after the stand speeds have been selected. This equipment has been installed on a stretch type pipe mill in Germany. Maintenance records for this mill on continuous duty indicate only about three per cent of the total pipe plant downtime is due to the stretch mill. Movies taken of the operation of the mill showed that roll speed ratios between successive stands do not vary more than ¾ per cent for a condition of peak load on one stand and idle load on the next stand, and only 0.03 per cent for full load on both stands.

Rotary gang slitters are being installed by users of steel, who estimate they will save appreciable money by in-plant slitting of coil strips which they previously purchased slit to specification. One unit has a production of nine tons per hr, and also gives close control on tolerances. The line is delivered as an assembled package unit. One operator can handle a line and slitting speeds run from 50 to 200 fpm.

A new unit specifically designed for joining the ends of coils in continuous process lines has been installed in several plants. This machine's components are entry and exit pinch rolls, entry and exit strip centering devices, transfer carriage with independent clamp jaws, double blade up-cut shear and die set, welder-trimmer unit, roller lift and roller hold-down devices. It is claimed that the weld properties are excellent and that it is not necessary to slow down the strip when the welds go through continuous mills.

The new specialty merchant bar mill which is scheduled to go into operation early in 1956 at Northeastern Steel Co. features flexibility of operation and automatic controls. Motors driving the mills are listed as follows:

Application	Motor hp	Motor speed, rpm
1 — 20-in. reversing mill	1250	60/180
1 — 18-in. three-high mill	2000	800
2 — 14-in. mills	1000	400/800
2 — 14-in. mills		
1 — 12-in. mill		
1 — 12-in. mill	500	400/800
1 — 10-in. vertical mill	300	400/1000
1 — 10-in. horizontal mill	300	400/1000



A combination mill is being installed by Northeastern Steel Corp., at Bridgeport, Conn.

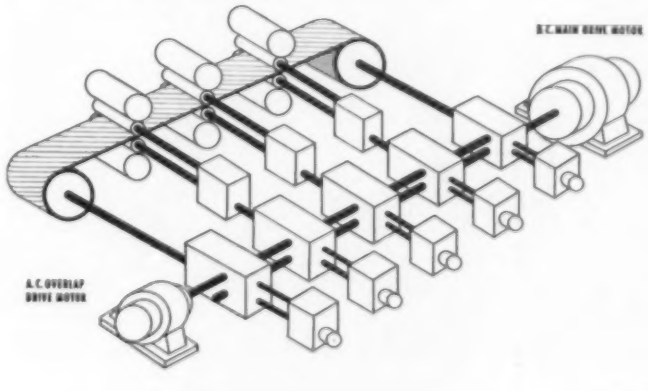
A $4,500,000, 15-stand bar mill is being built by Rotary Electric Steel Co. and is expected to be completed in the second quarter of 1956. The mill will have a total driving horsepower of 3800 hp. It will be used to produce stainless steel rod and bar under the company's present range of ½ in., particularly to supply new stainless wire drawing facilities. The mill will add 132,000 tons of hot roll bar capacity to Rotary Electric.

U. S. Steel Corp. completed their rail mill improvement program at Edgar Thomson Works. An interesting feature of the new setup is a rail end hardening unit which will harden one steel rail every 90 seconds and can heat-treat 18 rails 39-ft long at a time. Two similar units were installed in 1954, although they can handle only 12 rails at a time. The new unit consists of four preheat burners which use natural gas, one superheat burner and a forced air quench.

Colorado Fuel & Iron at Claymont, Del., completed installation of a 3000-ton push-through press which is one of the largest and fastest in the world. This press is capable of producing heads up to 10 ft in diameter. At the present time, the press is equipped for cold forming, but a new heating furnace under construction will enable the press to be used for either hot or cold operations.

There was a great deal of activity in the pipemaking industry. National Tube Division of U. S. Steel started

Sketch shows application of mechanical drive section to multi-stand cold strip mill.



a two-fold program to increase production of oil country tubular products. Construction was started in January on facilities which will triple production of deep-well casing at National Works in McKeesport. Additional equipment for treating and finishing the pipe is receiving great emphasis in this program. At Lorain Works, a new upsetting unit is being installed. This will increase production of external upset API tubing in the 2⅜ to 4½ in. outside diameter range. The process increases the wall thickness at the end of the pipe to permit the threaded end to be as strong as the body.

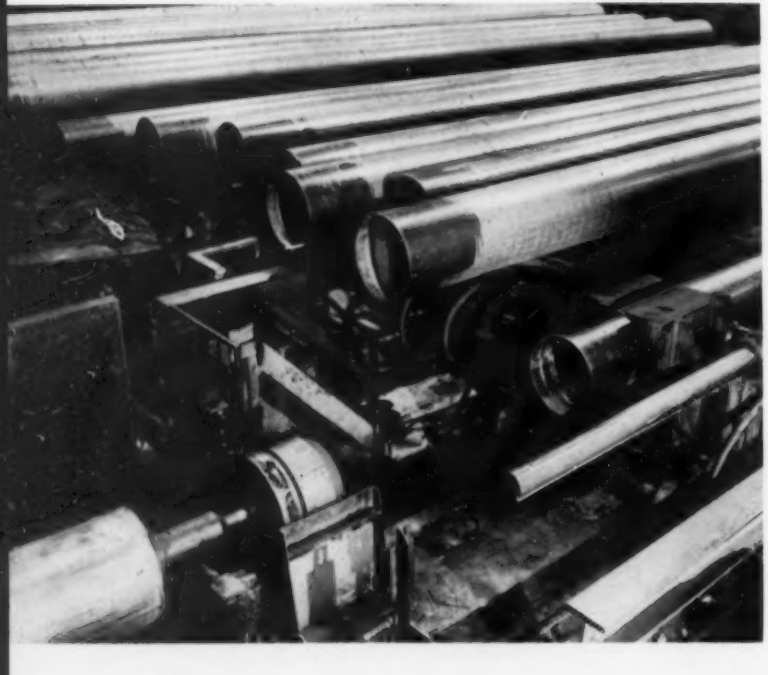
The industry's shipments of deep well and N-80 casing which, at the beginning of the year was about 25 per cent, is increasing, and consumers estimate that about 40 per cent of all casing must be high strength to meet future requirements because of the increased depth to which wells are being driven.

Cold expansion of seamless is now accomplished at the Lorain Works of National Tube with a process that uses a two-piece, 1000-lb plug attached to a mandrel made of 14 in. heavy wall seamless pipe. About 300,000 lb of thrust on the mandrel forces the plug into the pipe, expanding it in sizes ranging from 16 to 26 in. in diameter. A 500-hp motor is used to drive the mandrel. The expansion plug is followed by a highly machined alloy ring. A water-soluble lubricant is applied to the inside of the pipe ahead of the plug to reduce friction. After leaving the opposite end of the pipe, the plug drops from the mandrel onto an elevator and a conveyor that return it to the starting point.

The expanding process shortens the pipe several inches in length depending upon the size of the pipe and the degree of expansion. Wall thickness changes only slightly. The amount of expansion varies, but 23⅓-in. pipe can be expanded up to about 24 in.

One of the current items on Bethlehem's $200,000,000 two-year expansion program is equipment for fabrication of welded pipe. This pipe is to be expanded hydraulically to increase its strength about 25 per cent. Expanded pipe will be made with wall thicknesses up to ⅝ in. in diameter in lengths up to 40 ft.

The mandrel bar on a new cold expander unit at the Lorain works is inserted into the circular expanding plug unit which is forced through the pipe at thrusts up to 300,000 lb.



It is reported that the Allegheny Ludlum Steel Corp. has been able to produce a stainless steel and carbon steel composite tubing. The material is, however, not yet in commercial production. The tube is made by a combination of processes for the production of clad materials and hot extrusion. The tube produced so far has the stainless on the inside, although it is believed that the process can also be used for applying the stainless on the outside and for making a sandwich material of three dissimilar metals.

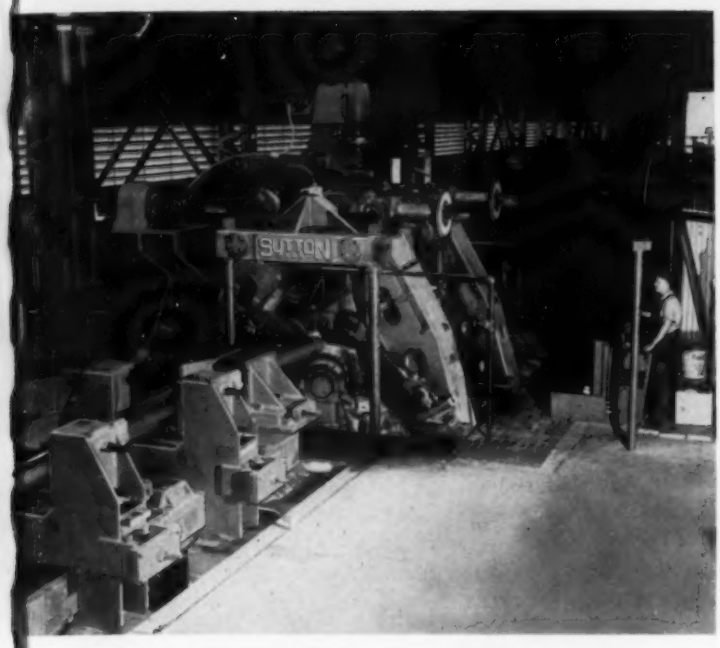
Construction was started by Mannesmann A.G. of Dusseldorf, Germany on a seamless steel pipe mill employing automatic processes. This mill will be located at Sault Ste. Marie, Ont., and will be adjacent to Algoma Steel Corp, which will supply steel requirements.

Accurate pipe straightening is being accomplished at the new pipe mill of Lone Star Steel on a 7-roll unit in which a large driven roll with two opposed idler rolls is located at the entry end of the machine, and another identical cluster is at the delivery end. In these clusters, the rolls are positioned at approximately 120 degrees to each other. Between these two three-roll clusters is an unopposed pressure roll. No guides are necessary. An interesting feature is the ability of the unit to handle pipe with externally upset ends at high production speeds. Automatic control of the angling of the rolls and power operated screwdowns make rapid size changes possible.

Unusual sizes and lengths of heavy wall seamless tubing, which previously could only be obtained in Europe, are now available in the United States due to the construction of a rotary forging seamless tube mill at Phoenix Iron & Steel Co. Heavy wall seamless tubing is available in sizes from 5½ to 16 in. outside diameter in lengths up to 50 ft. Wall thicknesses can vary from ¼ in. to 3 in.

In the process, a bottle bloom is formed by a hydraulic piercing press which forces a ram into the ingot. As the ram pierces through the center of the ingot, it expands it. This bloom then goes into an elongator which is essentially a modified piercing mill. Two rolls grip the forward end, rotating the bottle and advancing it over a piercer point. This combined action increases the inside diameter and reduces the outside diameter slightly. After the bottle has been properly elongated, it is completely pierced to form a hollow bloom, which then goes through the scarfer, is reheated, and goes through a second elongater. Next, the bloom goes to a rotary forging table, where a water-cooled mandrel is inserted by a feeder which is automatically controlled and synchronized with the roller speed. The feeder moves the hollow bloom and mandrel a specific distance with each stroke of the specially shaped forging rolls. The mandrel and bloom are turned 90 degrees with each stroke of the forging rolls. This is continued to within several inches of the end of the bloom. The pipe is then normalized and sized.

A new plant was also completed for production of tubing by the compression forming process. Up to now the process had been used primarily for tubing up to



New straightener gives improved product.

5.75 in. outside diameter. The new plant will increase the size range up to 17 in. outside diameter. One of the important advantages of the equipment is the ability to shape large, thick-walled tubes into products with precise finished shape or size. Fabrication is very similar to swaging machine operation. Tapered sections are also possible by the method.

U. S. Steel Corp.'s National Tube Division introduced a polyvinyl chloride plastic pipe which makes this the second kind to be extruded by the corporation. Early in January, polyethylene was put into production at Gary. This second plastic is a new material which has excellent properties for certain applications.

Republic Steel Corp. also announced that they will double their production of plastic pipe by the installation of facilities at the Cleveland plant. Previous to this time, Republic's production had come from its plant at Magnolia, Ark., which was bought in 1953.

It is reported that a new automatic welding machine which has been shipped to Europe from the United States is able to make cold-formed welded pipe at speeds up to 40 fpm from plate ½ in. thick and up to 20 in. diameter. On smaller sizes, speeds go up. On another similar mill, removable and interchangeable roll stands will be built to reduce downtime.

A magnetic non-destructive testing machine is being used at an eastern steel plant to check welded, non-magnetic, stainless steel tubing up to about 4 in. in diameter. The machine operates at speeds up to 400 fpm. The machine works automatically and not only checks for holes, cracks, welding imperfections and flaws, but can also pick up certain types of defects under the surface. The manufacturer of the machine states that any non-magnetic metal can be tested.

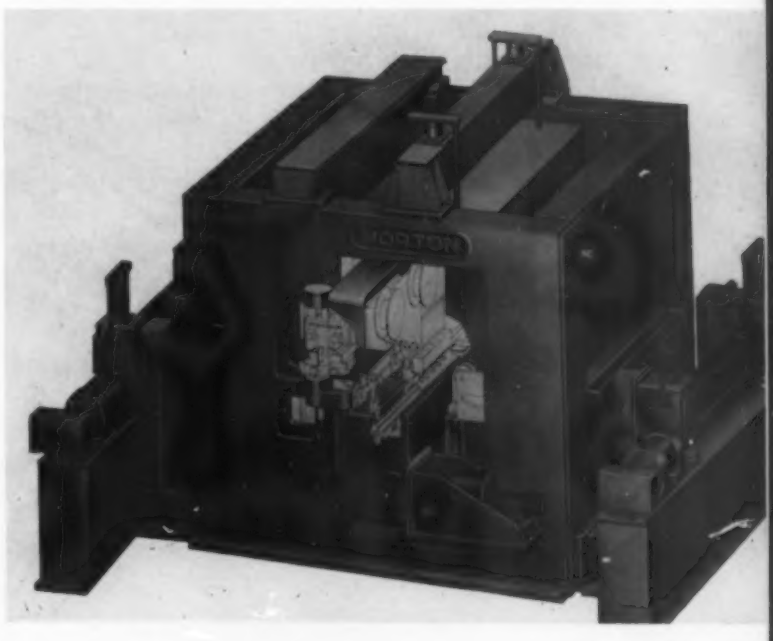
The use of automatic calculating machines in the handling of data for production control is a new development in industry. One of these programs has been carried out by U. S. Steel Corp. and is called integrated data processing through common language machines. Unusual features of the process are that original data are processed at their point of origin in mechanical form. Once they are in mechanical form, they are handled afterwards entirely in a mechanical manner, and all processing of data is so integrated that the original data in mechanical form will serve in all subsequent applications. A five-channel punched communication code is defined as the standard common language.

One application in the steel plant has been to control the wall thickness of hot rolled seamless pipe. In the process, as the hot rolled pipe passes over a cooling table, a production measuring device measures the length and weighs the pipe. From the actual weight and length, the equipment calculates the actual weight per ft of each pipe and this data is flashed to the mill operator through an illuminated board. Since the operator knows the specification weight, this indication allows him to take corrective action in case the product varies from the specification. By reducing the amount of overweight product, increased yield is given for a particular weight of steel.

A similar type installation on a slab mill should also result in production economies. Load cells are being installed under the ingot turning mechanism ahead of the mill. A weight signal will be received from this location which will go into a computer and a gage will signal the operator before the ingot is rolled. Thus, instead of holding gage on the light side to insure the required slab length, the operator can hold gage on the heavy side. Thus, material will be conserved and increased coil length will be obtained from the slab when it is rolled into strip.

The use of magnetic particle inspection on billets by Timken has resulted in a number of advantages in time, cost and labor. Of interest is the fact that pickling has been eliminated entirely. Handling is greatly reduced, and is done automatically. Magnetization of the billet takes place under a pipe through which the magnetic particle suspension is poured. After the billet has been completely wetted, it is ejected from this sta-

Welding unit for flat rolled product gives joint which can be run through subsequent processes without slowdown.



At Edgar Thomson works of U. S. Steel, both ends of 39-ft rails can be heat-treated simultaneously. Unit was put into production during the year.

tion and rolled into an inspection station. The billet rests on rollers, permitting the inspector to rotate it for inspection of the entire surface under ultra-violet light.

Billets are marked by the inspector to show defects and these then go to two manual scarfing stations. Instead of using an oil suspension for the magnetic particles, because of the fire hazard, water was substituted and found to be more economical. Antifreeze has been used to lower the freezing temperature and burners may be used under the charging bed to prevent freezing of the solution.

After Timken adopted hot scarfing for conditioning steel billets, it was found necessary to handle the iron oxide dust which results from this operation. This dust is prevented from going out into the atmosphere through construction of a dust-settling chamber on the roof of the hot scarfing building. Four 30-hp blowers pull the oxide-laden gases through ducts and 7000 to 9500 lb of iron oxide are collected each week, or 2 lb for each ton of steel processed.

An automatic billet grinder developed at the Halcomb plant of Crucible Steel has a number of unusual features. Compared with the conventional swing grinder, the new equipment gives increased production, better grinding and more flexible control. The new grinder standardizes the quality of the grinding since the pressure is mechanically regulated and uniform pressure can be obtained throughout by manipulating the proper controls.

The control on the grinder is such that the billet can be turned over automatically even while the machine is in operation. It is also possible to spot grind with the equipment. Table and transverse motions on the unit are hydraulically controlled and the other motions are under pneumatic control. Corner grinding can also be done on the machine without overgrinding. The grinder is also equipped for fully automatic operation and by setting the controls for the desired number of grinding passes per side, the machine will completely grind all four sides of the billet and come to rest in the discharge position.

What is believed to be the largest draw bench ever built, as far as physical size is concerned, was shipped during the year to a non-ferrous plant. This unit has a maximum pull of 150,000 lb at 100 fpm and is designed to be used at four draw speeds of 110, 165, 220 and 330 fpm. One of the features of the bench is the air-operated carriage head.

Production of extruded solid carbon steel sections by the Ugine-Sejournet process was started at Jones & Laughlin's new hot extrusion plant in February. The extrusion press is horizontal, hydraulically powered and operates at pressures up to 1000 tons. Production sequence is automatic. Billets vary from 4 in. in diam and 6 in. long to 5 in. in diam by 20 in. long, with a maximum weight of 110 lb. An induction unit is used to heat billets in an inert gas atmosphere.

Powdered glass is used as a die lubricant. The extruded bar is stretcher-straightened and detwisted. A shot-blasting machine then cleans glass and scale from the bar. Conventional cold-drawn equipment is used to give final dimensional accuracy.

In this process die making and die life are important factors in the economy of the operation. After some experience there are indications that dies made from certain alloys of the austenitic type give better life, apparently because of the indifference of this type of steel to the temperatures encountered in the operation.

The advantages of the hot extrusion process lie primarily in new and improved sections which reduce machining costs to the consumer. Basically, the operation is for small quantities and only advantageous for the higher quality steels.

Allegheny Ludlum also has an extrusion plant in operation. Its efforts have been directed largely to tool steels and air frame components.

Companies now in the extrusion field are Babcock & Wilcox, which started early in 1952, U. S. Steel and Allegheny Ludlum, which started in late 1952, H. M. Harper Co., which started in the middle of 1954, and Jones & Laughlin Steel Corp., which started in 1955. Except for Jones & Laughlin, most of the efforts have been directed at producing hollow sections.

Magnetic particle inspection is now being used on semi-finished steel in mill production.

A large portion of the Air Force heavy press program went into production during the year. Among the units which went into operation were a 50,000 and 35,000-ton forging press at Wyman-Gordon Co., a 50,000 and 35,000-ton forging press at Alcoa's Cleveland plant, three 8000-ton extrusion presses—two for Kaiser at Halethorpe, Md., and one for Harvey Machine at Torrance, Calif., two 12,000-ton extrusion presses, one for Curtiss-Wright in Buffalo and one for Harvey at Torrance, Calif. The first press in this program, a 13,200-ton unit went into operation at Alcoa's Lafayette, Ind. plant in July 1954. A 25,000-ton forging press which originally had been destined for Kaiser's Newark plant was placed in storage.

An 8000-ton forging press was also installed at Alcoa's Cleveland Works last February. This unit is not part of the heavy press program, because it is under the 10,000-ton size for forging presses.

Thus at the end of 1955 there was a total of about 104 extruders, handling aluminum primarily, with a production of about 300,000 tons. This compares with a total of eight extrusion units in 1947.

FINISHING

To meet the demand for galvanized sheets, about 2,900,000 tons were shipped in 1955. Additional capacity will be provided by lines under construction.

Among the lines under construction were one for Dominion Foundry & Steel Co., Ltd., Canada, one for Inland Steel Co. for widths up to 60 in., one for Jones & Laughlin Steel Corp. in Pittsburgh, and one for Richard Thomas & Baldwins, England.

Republic Steel's new continuous line was completed during the year at Warren, Ohio. This line is the fourth to use the process developed at Wheeling Steel Co. Two others are installed at the Martins Ferry plant of Wheeling Steel and another at the Steel Company of Canada's plant at Hamilton, Ontario. Two other lines under construction which will use the process are at the Dover, Ohio, plant of Reeves Steel & Mfg. Co., and at the Gadsden, Ala., plant of Republic Steel.

Richard Thomas & Baldwins, Ltd., are installing an Armco type continuous galvanizing line which will have a potential capacity of 10 tons per hour of 48-in. wide strip.

There was much activity on tinning lines. A new electrolytic line was completed by U. S. Steel this year. Weirton Steel Co.'s new line will start in 1956. Youngstown Sheet & Tube Co. will have the new one in operation by 1957, and Bethlehem Steel expects to have two new electrolytic lines completed in 1957.

The new No. 5 electrolytic tinning line under construction at Weirton will run at speeds of 2000 fpm, plating steel strip up to 45 in. wide. This line is designed for horizontal strip travel and will have 32 plating cells, 21 on the first deck and 11 on the second.

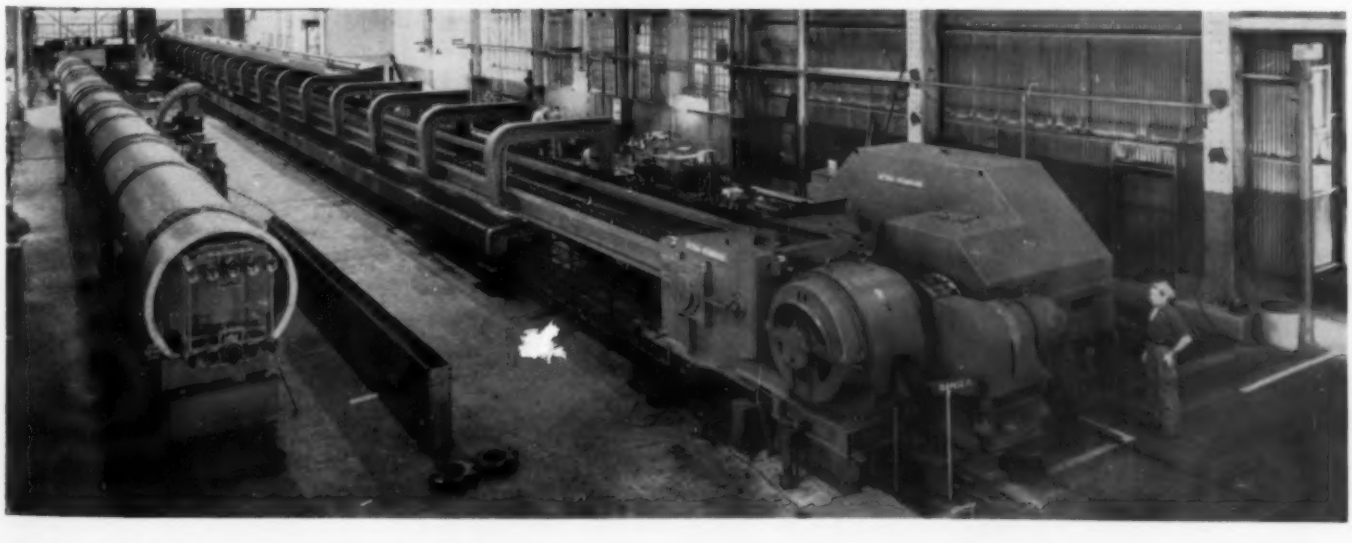
X-ray gages have been developed by Jones & Laughlin Steel Corp. to measure the amount of tin applied during the plating operation. These have been installed in all three electrolytic lines at J&L's Aliquippa Works. Thickness of tin can be measured to within 0.0000006 in. An instrument records permanently how much tin is applied on each particular coil. The gage is based on the phenomenon of X-ray fluorescence.

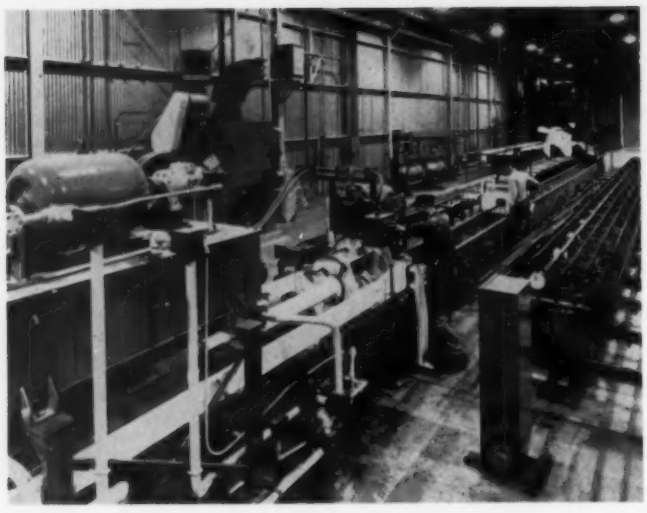
A redesigned pinhole detector for strip steel has a sensitivity five times greater than former models. Under operating conditions, the unit will detect holes down to one mil diameter in opaque strip measuring 10 mils or less in thickness. The gage will function at maximum sensitivity at strip speeds up to 2000 fpm. Laboratory tests indicate a potential in excess of 6000 fpm. The unit can be used on strip up to 48 in. wide. To obtain this performance, the light intensity was increased ten times and a single mercury vapor lamp is used instead of 21 small projection lamps previously used.

A line of rolls for finishing lines of all kinds was put on the market in 1955. These rolls are covered with a thermosetting laminated plastic. By varying the fabrics and the plastics, rolls can be made with different characteristics to meet almost any operating conditions. Foreign particles do not imbed themselves in these rolls, as with the conventional rubber covered rolls, and as a result there is less strip marking. Rolls can also be made which are acid proof. Applications in electrotinning lines, pickling lines, cleaning and galvanizing lines, etc., are proving successful.

A new process developed by the Page Steel & Wire

Draw bench, with 5-draw carriage head, can be used for pulls up to 150,000 lb. View shows mandrel and draw bench side by side, but in actual installation, the two sections will be in line.





Extrusion press put into operation by Jones and Laughlin is used primarily on solid sections.

Division of American Chain & Cable Co. applies a coat of aluminum to iron and steel wire. In the aluminizing process, the steps consist of preheating, cleaning and pickling in hot acid solutions, rinsing in hot water, application of flux by immersion in a salt solution, and finally, immersion in a molten aluminum bath. The wire is then withdrawn vertically to give a uniform coating. The flux is a hot aqueous solution of zirconium or titanium fluorides or a complex zirconium or titanium fluoride with an alkali metal such as sodium or potassium. Temperature and concentration of flux are varied to suit the diameter and speed of the wire. Coating weight and thickness are controlled by the speed of travel.

Armco Steel Corp. has developed a new type of aluminum coated steel which is being produced in sheet and coil form in widths up to 48 in. This material is applicable for exterior use. Molten aluminum is applied to cold rolled sheet through a continuous pretreatment and immersion process.

Several steel companies are also making plastic coated sheets on an experimental basis. For many applications the product offers good market possibilities.

A new food can has been developed which has an aluminum coating instead of tin, and sideseams that are welded instead of soldered. This entirely tinless can was developed as part of a program to eliminate tin and other hard-to-get raw materials from metal containers. The welded side seams not only eliminate the use of tin and lead solder, but provide a stronger can than conventional soldered types.

Blast cleaning is expanding its uses. First installations were used on flat rolled products. One plant has, however, a four-wide wheel machine which is in limited operation on blooms 15 x 15 in., and slabs 22 in. wide by 20 ft long. A scouring process is used instead of a direct vertical blast, and this has apparently overcome the problem of embedded shot which has been an objection to the use of blast cleaning for billets and slabs. In another installation, skelp from 73 to 92 in. wide has its edges cleaned by four air blast units. Each gun cleans a band 3 in. wide.

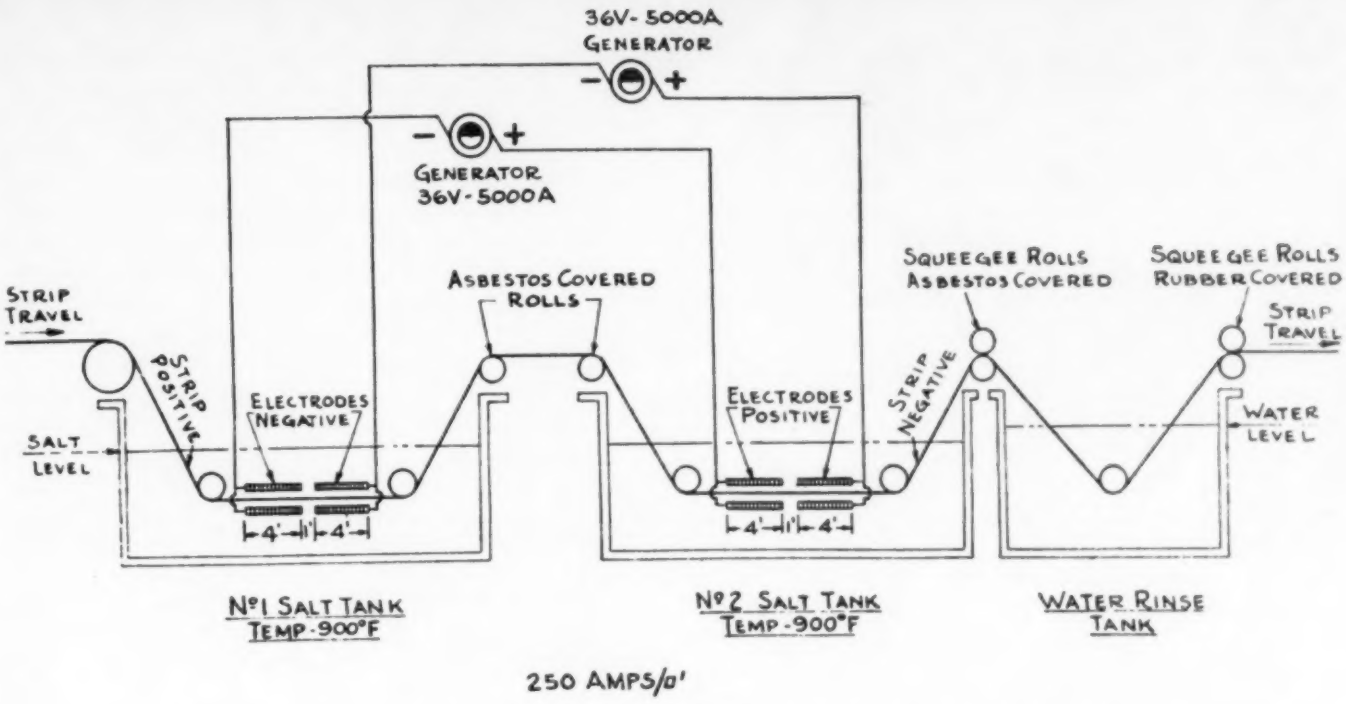
Experience on the shot blast installation at Empire Steel shows that the blasted strip can be flash-pickled in 16 per cent acid at 200 F in only a 13-second immersion, compared with about one minute for normal straight pickling. The descaler also gives the surface an etched finish which gives a better bite in the cold mill. Preliminary results indicate that cleaning costs are lower than that of straight pickling.

The pickling line at Atlas Steels, Ltd., is rather unique in that the same line is used for continuous descaling of both hot and cold rolled stainless strip. Both straight-chrome and chrome-nickel grades are handled on the line. Two descaling salt pots are used; in one the scale is oxidized and in the other, the oxidized scale is dissolved. The line can handle two strands of strip up to 19 in. wide simultaneously. After the strip goes through the two descaling pots, it passes through the pickling unit. Annealing furnaces are also a part of the line.

It is believed that Atlas is the first mill to adopt this electrolytic salt descaling process for commercial production. The salt baths (substantially sodium hydroxide) operate at a temperature of about 900 F, and are heated by gas-fired immersion burner tubes. A negative set of grids is installed in the first descaling pot, which is insulated from the second unit, where there is a positive set of grids. Current, supplied at 18 volts, 5000 amp, from two motor-generator sets, passes through the strip.

When cold rolled, annealed stainless is processed, it is not necessary to supply current to the descaling bath. Then the generators are used on the nitric acid or sulphuric acid tank for electrolytic pickling. Equipment for the combination line consists of a quench unit, two

Two giant presses shown are installed at the USAF heavy press plant at Alcoa's Cleveland, Ohio works. In the foreground is a 35,000-ton unit, and in the background is a 50,000-ton press.



A hot salt electrolytic bath is used for continuous descaling of steel at the Atlas Steels plant.

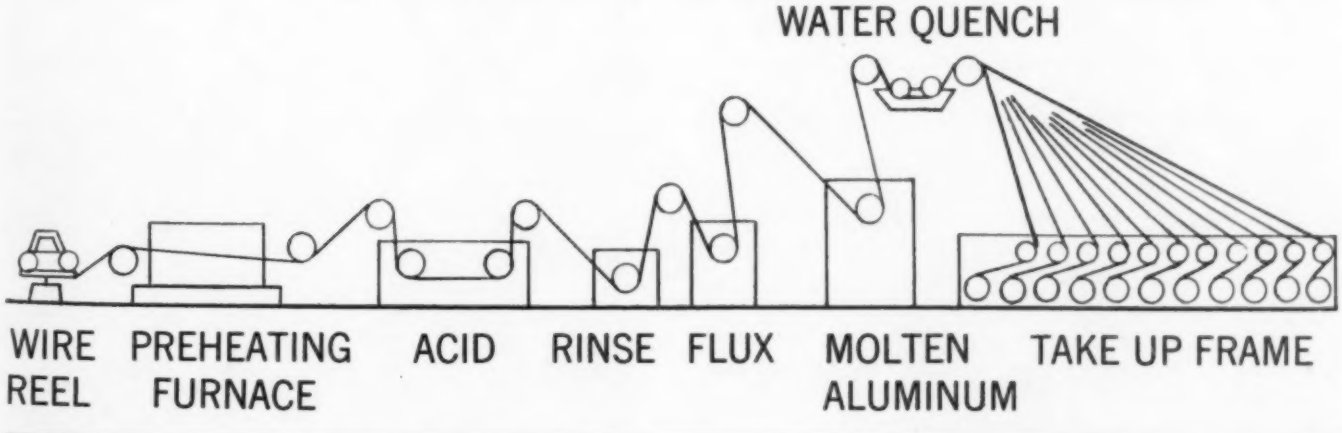
tanks of a salt descaling solution, a water quench, support rolls, hot sulphuric acid tank, support rolls, an electrolytic sulphuric acid tank, support rolls, and then a hot nitric-hydrofluoric acid tank and scrubber.

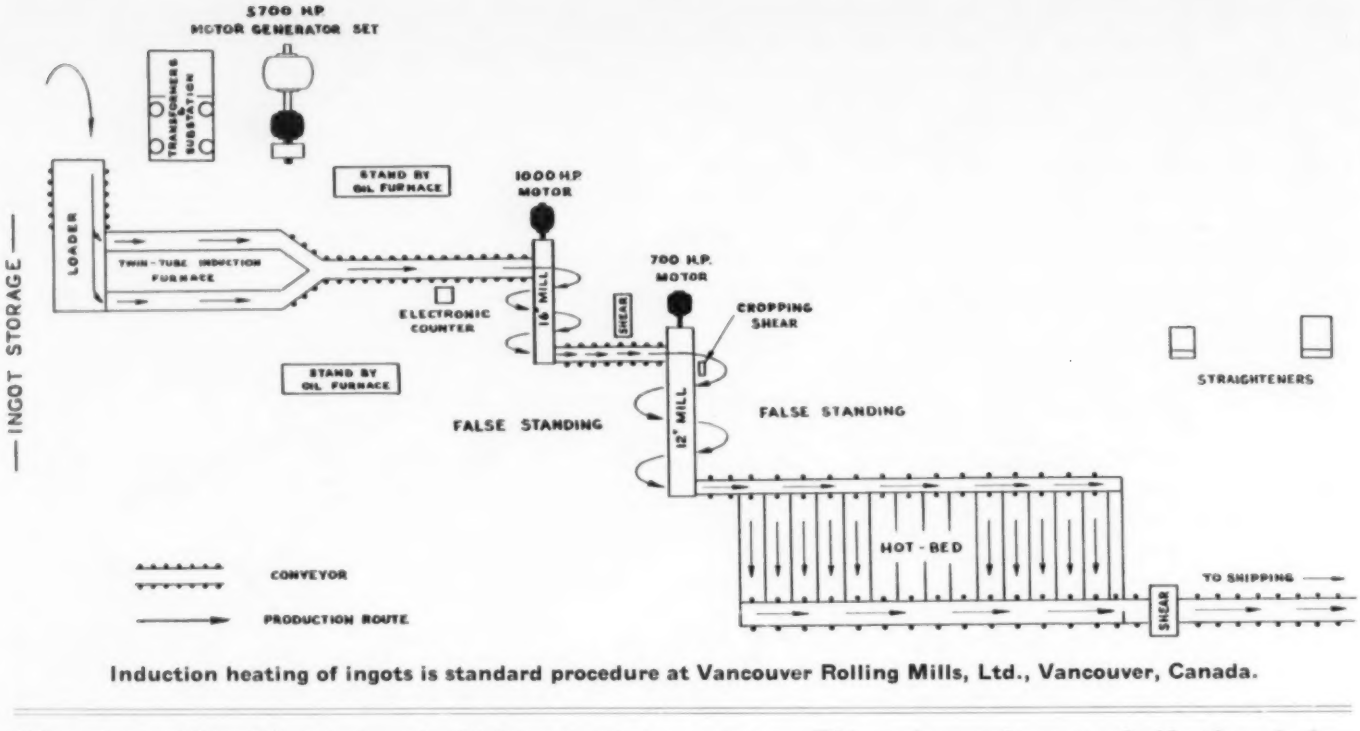
Stainless and heat resisting steels can be pickled without acid in a new process introduced from Germany. The process starts with a fused-salt type bath. This pretreatment changes the scale to one which is more soluble in mineral acids. Instead of using acids, however, the German process passes it through a reducing atmosphere of cracked ammonia or bottled hydrogen. This converts the surface to a bright clean finish.

A demonstration plant is to be constructed which will use the Ruthner process for pickle-liquor treatment. This is a cooperative project being financed by Republic Steel, Jones & Laughlin, National Steel, U. S. Steel, Youngstown Sheet & Tube, Wheeling Steel, Pittsburgh Steel, and the sponsor of the process, the Blaw-Knox Co. The pilot plant, to be built at an estimated cost of about $250,000, will be located at the

New wire galvanizing unit at Los Angeles plant of Bethlehem Pacific Coast Steel Corp. can handle 40 strands of wire at one time.

Schematic layout shows steps in aluminum coating of wire.





Induction heating of ingots is standard procedure at Vancouver Rolling Mills, Ltd., Vancouver, Canada.

Niles plant of Republic Steel, and will have a rated output of 650 tons of sulphuric acid a year. If the pilot plant works out, a much larger commercial plant is planned which will be located in a location which is convenient to several steel mills. Operation is expected sometime at the end of next summer.

The process, in general, consists of concentrating sulphuric acid pickle liquor by partial evaporation, reacting the concentrate waste pickle liquor with hydrogen chloride gas, and centrifuging the reacted mixture of sulphuric acid and ferrous chloride. The ferrous chloride is roasted to produce hydrogen chloride and iron oxide, and the hydrogen chloride gas is recovered by an absorption stripping system for recycle to the process. The ferrous sulphate in the liquor regenerates an equivalent quantity of sulphuric acid which can be again used for pickling. It is believed that this process, instead of showing a loss as most pickle liquor recovery processes do, will under favorable conditions show a profit. No undesirable by-products are left.

The steel industry continues its efforts to eliminate stream pollution. Among companies which completed important work are Armco Steel at Middletown, who completed a million dollar coagulation and clarification system to remove finely divided iron scale from waste waters. This unit supplements clarification devices which had been previously installed for the removal of heavy mill scale and for flue dust recovery from blast furnaces. The company also installed a new phenol recovery system.

The Youngstown Sheet & Tube Co. reduced, by 86 per cent, phenol losses by means of a good housekeeping program. Improvement was obtained through elimination of unsuspected leaks, changes in operating procedure and adoption of a preventive maintenance program.

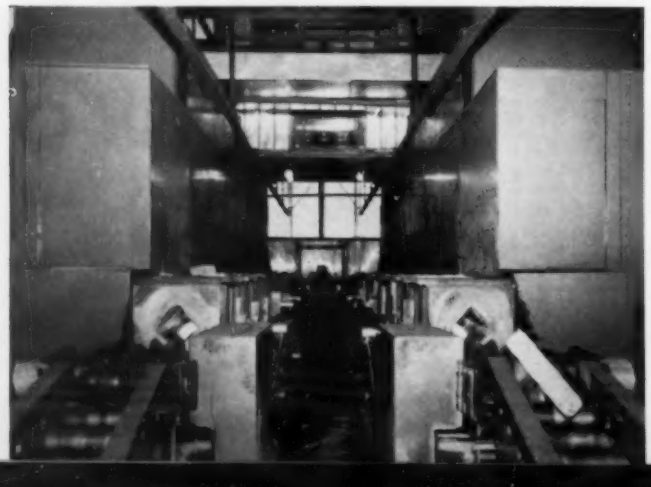
The Weirton Steel Co. at Steubenville began construction of sewers which will segregate sanitary sewage from industrial waste. This will permit treatment of the sanitary sewage from the plant in a municipal treatment works now under construction.

Weirton Steel also completed a million dollar recovery system which will prevent discharge of about 200 tons daily of blast furnace flue dust. Contracts were also let for a new phenol recovery system for the by-product coke plant.

FURNACES AND CONTROL

There were a number of novel installations of heating units during the year. One interesting unit is the

Ingots are shown coming from each of the twin tubes of the induction furnaces.



Induction heating facilities are also used for Jones and Laughlin's hot extrusion plant.

new integrated heat treat line at Lukens Steel. This line handles plate up to 130 in. wide and 40 ft long, and from $\frac{3}{16}$ to 2 in. thick. A number of different steels are processed on the line.

A quench press is used at the end of the line. Production varies with the product, with 46,000 lb per hr for example, for heating and quenching $\frac{5}{16}$ in. thick, 40 ft long and 108 in. wide solid stainless steel plate. A 2-in. armor plate, 130 in. wide can be hardened at a rate of 50,000 lb per hr. Tempering of these plates is done at rates of about 33,000 lb per hr. The continuous line gives uniform heating.

A new type roller is a unique feature of the line. These consist of 14-in. diam rolls on 16-in. centers, made up of seven cylindrical sections of silicon carbide held together by heat resisting alloy end bells. The actual forces are transmitted by a central 2-in. water-cooled steel pipe which also cools the rolls. One man controls the entire line and television cameras show him operations at six points which he could not otherwise see. A similar furnace is also going into another steel plant.

Another plant will have in operation next year a unit which will heat treat structural shapes. By such heat-treatment, strength of structural shapes is practically doubled.

Weirton Steel Co. installed three new slab-reheating furnaces which are believed to be the largest built so far. Each furnace is designed to reheat 200 tons of slabs per hour. They are about 118 ft long and will accommodate slabs up to 26 ft long.

Republic Steel Corp. started work on a block of four new soaking pits at their Buffalo plant. Each pit will have a capacity of 14 ingots weighing about 6 tons each.

A new patenting furnace was installed at the Roebling plant. The patenting unit is coupled with a galvanizing furnace, providing a flexible unit for four basic types of operations.

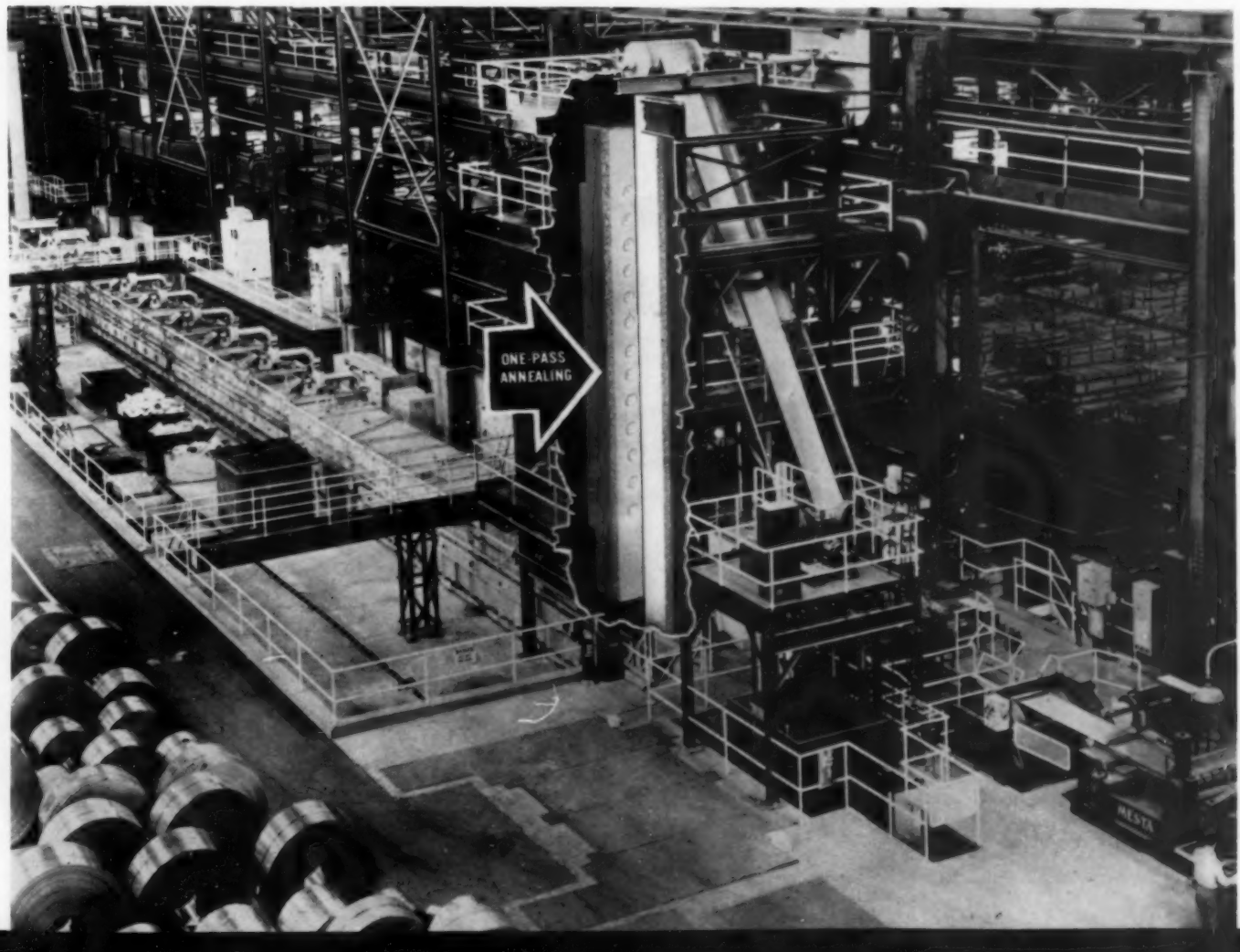
A controlled atmosphere furnace has been developed which gives a scale-free atmosphere at temperatures up to 2350 F. The burners are operated with about 50 per cent of the air needed for complete combustion. The air is preheated to get the required temperatures. The products of combustion have high percentages of carbon monoxide and hydrogen which provide the nonscaling atmosphere.

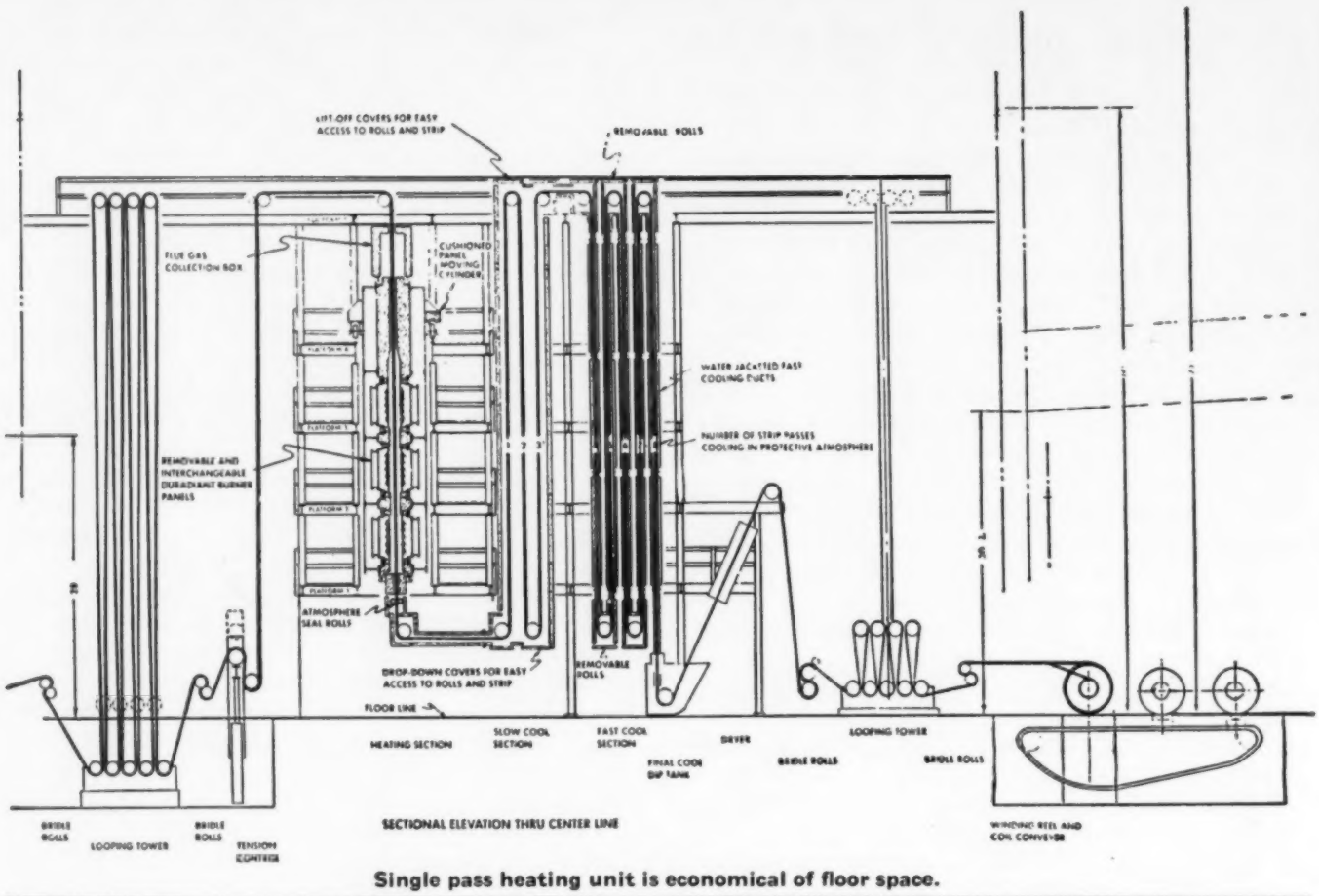
As the unburned gases leave the furnace, they go to the heating side of the recuperator where enough air is added to complete combustion. Thus, their heating value is recovered to help preheat the primary air.

A 60-ton per hr, 2000-fpm tin plate annealing line was installed during the year. This is about double the speed and capacity of previous lines. Higher speeds up to 3000 fpm are now being considered.

Four continuous annealing lines using high temperature heating are scheduled for operation in 1956. These units incorporate one-pass heating using direct radiation. Among the desirable features are that the overall length is short, and from the inlet of the heating section to the outlet of the cooling section is only 50 ft. Other space factors are a width of 23 ft and an overall length of 180 ft.

One-pass annealing is used in this 48-in. continuous galvanizing line.





Single pass heating unit is economical of floor space.

Similar heating units are finding many applications also in galvanizing lines. The design is similar except that the cooling is performed in a horizontal elongated cooling chamber. The elongated chamber is more suitable for galvanizing operations than the vertical cooling section in the normal annealing line. The principle in the operation of both is the same. The temperatures are similar. Cooling area is the only primary difference. A galvanizing line of this type has been in operation at the Sparrows Point plant for several years. Another line of the same capacity was installed and put into operation in August 1955. A third line is also under construction at Sparrows Point.

Short cycle heat treatment is being used for low alloy pipe. The demand for stronger pipe has resulted in the installation of a number of heat treating lines. On one typical installation, a series of cylindrical gas-fired furnaces from 4 to 6 ft long are used, whose chamber diameter is only slightly greater than the largest diameter to be processed. The short cycle quench and draw treatment takes only about 10 minutes. The first such unit was installed at Spang-Chalfant's plant at Ambridge. A similar installation has just been recently installed at Colorado Fuel & Iron Corp. at Pueblo. The latter is set up in a U-shape arrangement. Similar high speed lines are in use at Lone Star Steel.

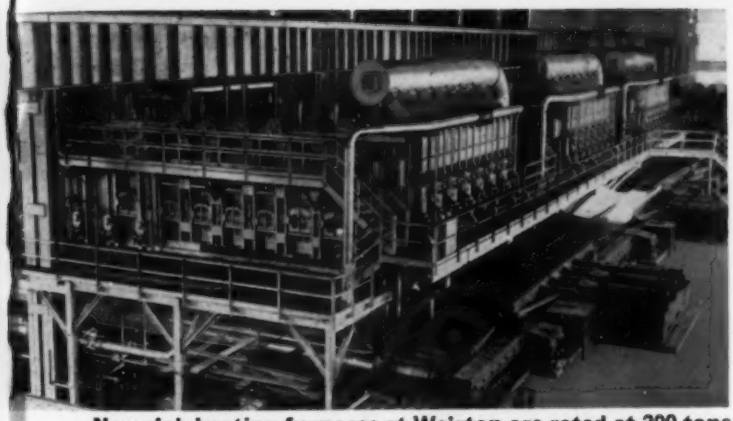
High speed heating is now being applied to sections formerly considered too large for this method. As an example, alloy steel die block 66 x 24 x 18 in. can now be heated to 1550 F for hardening in about 15 per cent of the time previously required. Reproducibility and uniform quality are obtained through automatic control of the complete heating cycles.

It is claimed that when the same rapid heating techniques are applied to heating ingots, capital investment is reduced and steel mill layout simplified. In one such installation, ingots of 19 x 23 x 78-in. are heated in a group of six holes constructed in pairs in three furnace shells. Four of these holes are fired by nozzle-mix radiant gas burners patterned in the side wall, and radiating heat uniformly on the ingot. Two of the holes, heated by waste products of combustion, are intended to preheat cold ingots with normally wasted products of combustion, after which the ingots are transferred to the radiant fired holes for finishing. Ingots are heated in a fraction of the time normally required in the average soaking pit.

In another installation consisting of two long units, a preheat and a high heat unit, ingots are loaded on a car and heated during the passage of the car through the two furnaces. This particular furnace can handle ingots ranging from 12 to 23-in. in diameter, and total heating time ranges from 55 to 160 minutes for a final ingot temperature of 2370 F. The furnace is capable of heating as much as 25 tons of large diameter ingots per hour.

Small steel ingots are being heated in a production operation by the electric induction method at Western Canada Steel Ltd.'s, Vancouver plant. Reports indicate that the new process cuts reheating time by about 75 per cent. Fuel costs are reduced about $1 a ton. Finishing capacity at this plant, which is an all electric semi-integrated steel plant, has gone from 40,000 to 70,000 tons per year.

There are two sections to the induction heating unit,



New slab heating furnaces at Weirton are rated at 200 tons per hr each.

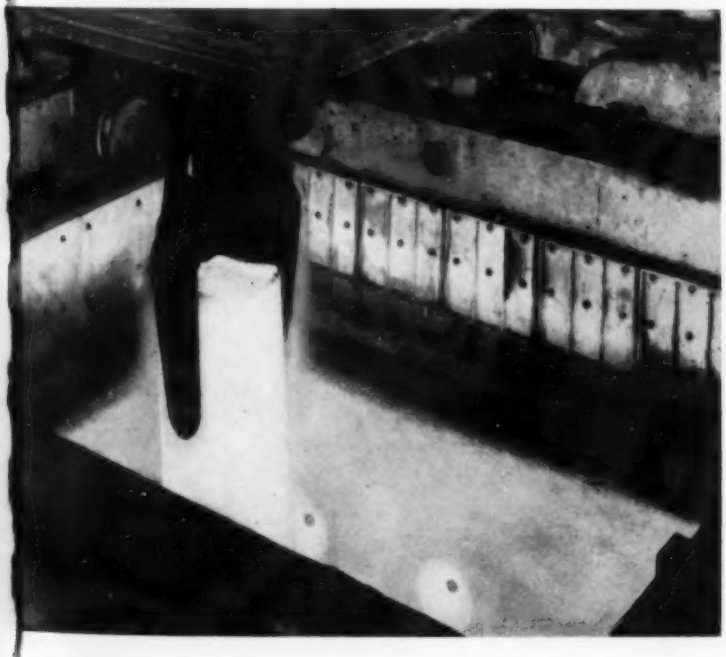
a 60-cycle section and a 540-cycle section. About half of the power used is supplied to the heating line at 60 cycles, 550 volts. A 3500-kw synchronous motor-generator set converts the remaining power to 500 volts, 540 cycles. About 7000 kw of energy are required. Power factor correction of the induction heating coils is important in the installation and capacitors are connected in groups to each coil group of both frequencies. The correction required varies in the different coil groups with the temperature of the billets passing through the heating coils. Average power factor throughout is better than 90 per cent.

Heating time is fast and varies from 3.6 minutes for the 112-lb ingots to 8.4 minutes for 466-lb ingots. Output varies from 15 tons per hr for the smaller ingots to 20 tons per hr for the larger ingots.

The coils presented the most serious maintenance problem. Originally stainless steel liners were used in the coils, but these broke down fairly quickly and they have been discarded and replaced with high silicon ceramic liners.

Results from this installation indicate that induction heating becomes profitable if the cost of fuel, plus scale loss, plus labor maintenance and overhead on the fuel-fired operation total $4 per ton or more.

High speed heating of ingots can drastically cut processing time.



A 60-cycle induction unit is used to heat 50-lb billets at 2300 F at the extrusion plant of Jones & Laughlin Steel Corp. The billets are heated in two steps, first to 1300 F in one coil and then to 2300 F in a second coil. The furnace will handle 4000 lb of 4 to 5-in. billets every hour.

A very large low-frequency induction heating unit was built for a magnesium plant. This will heat billets or rectangular slabs up to 32 in. x 71 in. long. It is rated at 2000 kw.

Fuels were in good supply in 1955 and it is expected that they will be plentiful this winter. The coal industry recovered from its low production of 362,000,000 tons in 1954 to about 450,000,000 tons in 1955. Gas production was up about 7 per cent to a total of some 35,750,000 therms. Residual oil production was about 557,000,000 barrels in 1955, a figure which should be adequate to meet demand.

A new technique for burning fuels in the open hearth is based on a novel burner design. A small amount of the fuel is burned with air in a chamber of the burner, and the gases thus formed are used to atomize the main liquid fuel stream. This eliminates the need for steam for atomizing. The procedure vaporizes the fuel and partially cracks it to give higher heat radiation levels.

One refiner has developed a process to treat residual oil by means of fluid coking. This turns the oil into a finished coke and a number of petroleum liquids, which can be further refined into gasoline and heating oils. Several plants are now being built. The coke has low sulphur and ash content, which makes it useful for such items as raw material for carbon electrodes.

The Bureau of Mines has been able to obtain methane gas by passing a synthesis gas over a nickel-alloy catalyst. This synthesis gas is being obtained from the gasification of coal and is a mixture of carbon monoxide and hydrogen. This development is part of the program for direct gasification of coal.

It has been found that the use of dolomite as an additive to fuel oil will help overcome the sulphur problem in fuel. The dolomite is mixed with the fuel as a slurry or blown into the fuel stream before it enters the furnace. Because this is a common and inexpensive mineral, it does not offset the savings which are gained from using low grade fuel oils. Several power plants are already adding dolomite to their fuel oils. As little as 0.001 lb of dolomite to one lb of fuel has corrected the sulphuric acid corrosion problem.

A joint committee on flame radiation research completed its new pulverized fuel furnace and experimental plant at IJmuiden in November in the Netherlands. Fundamental research on flame behavior and combustion has been carried on at this laboratory since 1949 by an international group. Some of the results emphasize the overall importance of the influence of fuel jet momentum on dimensions of the flame and its radiation. As a result of these studies, a quantitative value can be put on the influence of such variables as the type, quantity and inlet temperature of the fuel, type of burner and atomizing agent, and the quantity, temperature and jet momentum of the combustion air.

An important item in the transportation picture is a report by the examiner for the Interstate Commerce Commission which states that short and medium haul rail and truck freight rates on a number of steel products in the east were too low. This will undoubtedly affect rates.

A new type of freight car offers considerable savings in unloading time. This car is divided into five compartments with rugged partitions. The compartments are accessible from either side of the car by means of panelized overhead doors which roll up and out of sight. This five-compartment car permits single consolidated shipments of a variety of products in one freight car.

Handling costs for coils can be cut through the use of special coil cars equipped by the railroads specifically for handling coils. One railroad estimates that shippers can save $80 per car for blocking and dunnage alone. Equipment consists of skids which are installed two to a car with heavy-duty buffer springs at each end. Cross members are used to separate the coils. Cars have a capacity of 70 tons and each car can handle up to six 6-ft coils, or larger number of smaller coils.

After long study, the pipeline for moving coal was finally approved and construction will be started during the year. The pipeline will run from Georgetown, Ohio, to a location near Cleveland, some 108 miles. Estimated cost is about $10,000,000. The line will have a capacity of 1,200,000 tons of coal a year which will be moved in a slurry form. The Cleveland Electric Illuminating Company, who will receive the coal, will build a dewatering plant where it will be dryed before use. The line will be 10¾ in. in diameter and will transport coal at about 3 miles per hour by means of three pumps along the pipe line.

With the increase in steel furnace sizes, charging equipment is being made larger to speed up charging. One plant is using 60-cu ft charging boxes and another p'ant is considering 65-cu ft units.

A new open hearth charging method uses 50-ton tilting scrap cars instead of the ordinary small pan-charging buggies. A supercharger is used in combination with a conventional charging machine, and no changes are necessary in the usual open hearth furnace door and charging track arrangement.

Because of reduction in dead weight, the use of aluminum in electric overhead traveling cranes has been intriguing. However, very few have been bu'lt. One of the difficulties has been in the joint design. This year the largest aluminum crane and the first one which will be made of all-welded construction is being built for a large aluminum producer. Seven cranes have been ordered ranging from 100-ton capacity down to 10 tons.

Another intriguing possibility is the automatic crane. It is quite possible to set up a control scheme on a crane whereby the crane can pick up a load, move to a new location and discharge the load without the use of any manpower. One such installation, in the chemical industry, operates in an area in which workmen are excluded. These cranes travel to any one of a large number of points within the building area, locate the hoist over a specific point, lower a grapple, contact the load to be lifted, pick up the load, deliver it to a selected point and return to the starting point. In this particular case, the grapple can be positioned over the load with a tolerance of 0.01 in. This precise spotting requires specially designed trucks which operate on special flat machined steel rails mounted on adjustable supports, permitting the rails to be moved horizontally and vertically. Flat tread wheels without flanges are used on the crane. To prevent side motion, horizontal rollers are attached to the truck which ride against the sides of the rail. This construction on a substantial runway accurately locates the crane and trolley.

Earth moving construction equipment is being adopted in some plants for ore stocking purpose.

Some plants found it advantageous to switch from forged crane hooks to cast alloy steel crane hooks. These are now being made in capacities from 5 to 70 tons. The high strength alloy casting selected has a tensile strength of 120,000 psi and a yield strength of about 100,000 psi. This provides a 100 per cent increase in the safety factor. The hooks, in addition to being stronger, are also less expensive.

A new safety device permits workers to attend to a disabled crane without danger from other cranes on the runway, by warning of the approach or shutting off the movement of an oncoming crane. The distance at which this action takes place can be adjusted from 1 to 20 ft. The equipment consists of a receiver and receiver loop for each crane, and a portable transmitter with transmitter loop which is positioned wherever protection is required. These are tuned to the same carrier frequency. When the two come close enough together, enough energy is transferred from one to the other to actuate the receiver. The system is so designed that failure of any part will also give a warning signal.

Standard earth-moving equipment used by contractors has grown to such large sizes that the steel industry is finding good uses for them in handling of many bulk materials. One example is the use of earth-moving diesel units at Conneaut, Ohio, for stocking iron ore. Railroad cars dump ore into conveyor pits which feed

it onto an inclined conveyor system that dumps the ore into large scraper pan units. The pans then spread the ore in the stocking area. Shovels are later used to pick up the ore and move it directly into railroad cars for shipments to the mills. A number of plants are adopting similar practices.

MECHANICAL

There has been perhaps no technical field in which there have been so many new and fast moving developments as that of atomic power. Few subjects have had as much written about them, and few subjects have as little definite information available, since the field is in a constant state of flux. Figures are tossed about as to how many kilowatts of generated capacity will be built in 1975, 1980 and in the year 2000. Few statistics are available on what will be built in 1960.

The reason for this is that there are a number of different designs for reactors to generate atomic power. Proponents of the various schemes are working on plans, pilot plants and in some cases actual installations. A number of different companies and utilities are entering the field, primarily for two reasons: first, to develop knowledge of the field, and second, because our fuel reserves are such that if power requirements increase in the future as they have in the past, dependence must be put on additional types of fuel than are now available.

Much of the confusion of the program exists because so many decisions are necessarily political. Atomic fuels at present are still under the control of government, and apparently will remain so. Therefore, prices of the fuel are subject to governmental regulations. In addition, restrictions, rules and regulations on the handling of fuels can affect station design and cost. Operators of equipment must now be licensed by the AEC.

The Atomic Energy Commission has under way the 5-year reactor development program which was established early in 1954. This program is making investigations on five basic reactor types. Perhaps the one farthest along for commercial power is the pressurized water reactor plant being built at Shippingport, Pa., which will have a net capacity of 60,000 kw.

Last spring AEC issued its first set of regulations for purely commercial uses of atomic energy, and thus, for the first time, industry had a set of rules to govern it. Under the rules, however, the AEC still will own all atom fuel and will lease it out to users as needed. Other items in the regulations cover the keeping of strict records, security matters, protection of public health and safety, and the right of AEC to inspect at any time.

Among new power projects announced during the year was one for Pennsylvania Power & Light, which is to build a 150,000-kw unit with a homogeneous-type reactor. Service date for the new unit is 1962. In this type reactor, the fuel is in liquid form which also includes the coolant and moderator to control the fission process. The liquid circulates freely throughout the plant system and carries heat to the steam generators. The use of a liquid fuel system allows the addition of new liquid nuclear fuel while the reactor is running.

The Commonwealth Edison Co. in Chicago who are heading a combine known as the Nuclear Power Group, are building a 180,000-kw atomic power plant at a cost of about $45,000,000. The Consolidated Edison Co. of New York is also building a 250,000-kw power plant. In the latter case, however, an oil-fired super heater will be used to supplement capacity, as the reactor alone will produce only 140,000 kw.

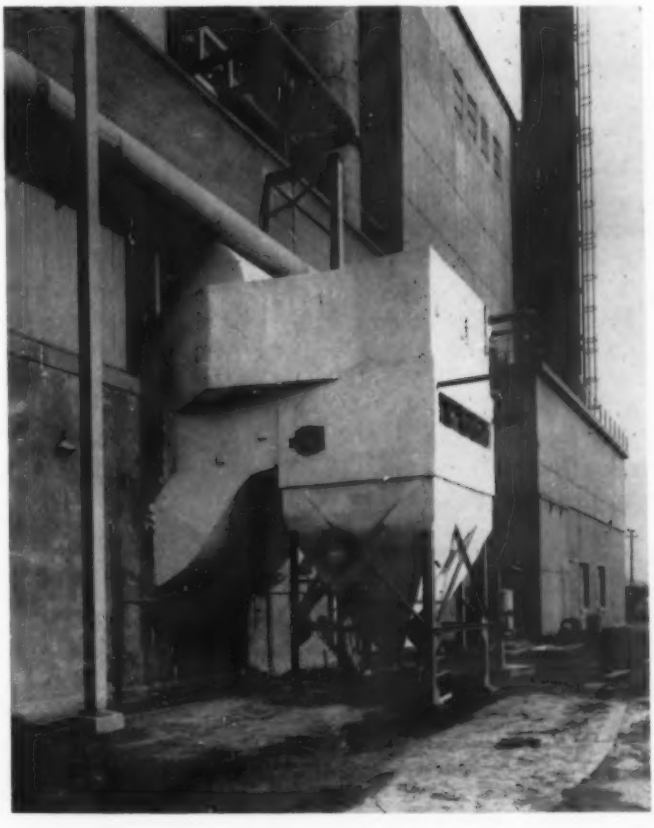
There are three other large scale projects under consideration. One is for a group of companies headed by the Detroit Edison Co., one for the Yankee Atomic Electric Co., a New England combine, and one for the Consumers Public Power District of Columbus, Nebraska. These groups represent a power plant capacity of about 520,000 kw at an estimated cost of about $185,000,000.

Future developments and costs will await the results that come out of the operation of these proposed plants.

Westinghouse Electric Corp. announced plans during the year to build a $6,500,000 materials testing reactor. These facilities will enable engineers to test materials under actual operating conditions and help solve one of the major problems which is holding up progress in nuclear power.

Atomic reactors are being applied to a number of military developments. The Navy has accepted delivery of atomic power submarines and others are on order. Extensive work is also under way on the use of atom-powered plants for merchant and naval vessels as well as aircraft. Orders have also been given for small nucelar power plants for the use of the Army in remote locations. At least two dozen reactors have been built in the United States.

The centrifugal dust collector on power plant boiler can be quite effective.



A number of reactors for power and other purposes are being built in other countries. The Hydro Electric Power Commission of Ontario is planning to build a 20,000-kw unit. In Great Britain, a 10-yr atomic power plan was announced which is much larger than the American 5-year plan. This plan calls for at least 12 nuclear power stations of which eight will probably be gas-cooled graphite moderated reactor plants. One reason for the greater push in Europe, and particularly in Great Britain, is the fact that coal reserves are smaller than in the United States. Plans are also under way for reactors in France, Italy, Norway, Netherlands, Belgium, Sweden and Switzerland. The First International Nuclear Congress held in Geneva in August showed that a great deal of progress in this field is taking place on both sides of the Iron Curtain.

In 1955, the first atomic-electric energy sold by the Government was fed into a public utility system in New York. This power came from the prototype submarine reactor. The arrangement was temporary, and a price of 3 mills per kwhr was set.

Estimates of the cost of building atomic power plants are going down, and one maker of combustion equipment estimated that a plant could be built for $210 per kw compared with about $160 for conventional power plants. The same source estimates power costs will run from 6 to 9 mills per kwhr.

Conventional power plants are exploring new fields. The first supercritical pressure unit is being built for the Philadelphia Electric Co. In this 275,000-kw unit, inlet steam pressure will be 5000 psi at 1200 F. The turbine consists of four casings, tandem compounded, with triple exhaust to the condenser at 1.5 in. of mercury absolute pressure. Steam will be reheated to 1050 F at two intermediate pressure levels. Regenerative feed water heating will supply boiler feed at 565 F.

In preliminary operation, it is planned to use 1150 F initial steam temperature. The plant heat rate is expected to be under 8400 Btu per kwhr at rated output, an overall thermal efficiency of 40.6 per cent. The generator will be rated 352,000 kva, 0.85 power factor, and will use inner-cooled rotor and stator conductors. It will be self-ventilated with hydrogen at 45 psi.

A second supercritical unit was ordered by American Gas & Electric Co. for installation at the Philo plant of the Ohio Power Co. This unit will supply steam to a 125,000-kw, 3600-rpm, tandem-compound, double-flow turbine at 4500 psig throttle pressure. It has a capacity of 675,000 lb of steam per hr at 1150 F total temperature, with two reheat stages: 1050 F at 1150 psig and 1000 F at 165 psig. Feed is at 5500 psig and 525 F. The expected heat rate for the unit is 8,500 Btu per kwhr.

One large boiler company, from its research work, foresees the development of commercial steam generators which will operate at pressures up to 10,000 psi.

A contract was signed during the year by a New York utility under which a boiler will be built which will have a capacity of 2,400,000 lb of steam per hr, sufficient to generate between 300,000 and 375,000 kw of electricity. Design pressure will be 2500 psi. One of the unusual features is that the boiler will be equipped to burn either coal, oil or natural gas, or a combination of these fuels.

Development has continued on the gas turbine. One railroad ordered fifteen 8500-hp gas-turbine-electric locomotives and has intentions of ordering an additional thirty.

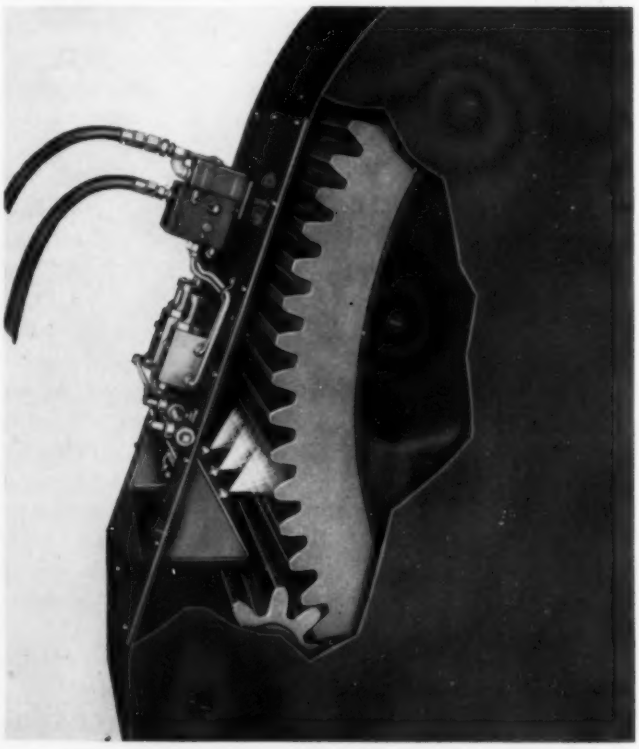
The first of two collector units for cleaning gases from a boiler plant at a Pittsburgh coke and chemical plant was put into operation during the year. This particular collector is designed for 41,000 cfm of dust-laden exit gases at 400 F. An efficiency of over 97 per cent was obtained from the unit. The collector consists of an inlet chamber connected directly to a nest of vertically-mounted separating tubes, a dust-collecting hopper, and a clean gas discharge chamber. This company installed this unit primarily to reduce fly ash from powdered coal.

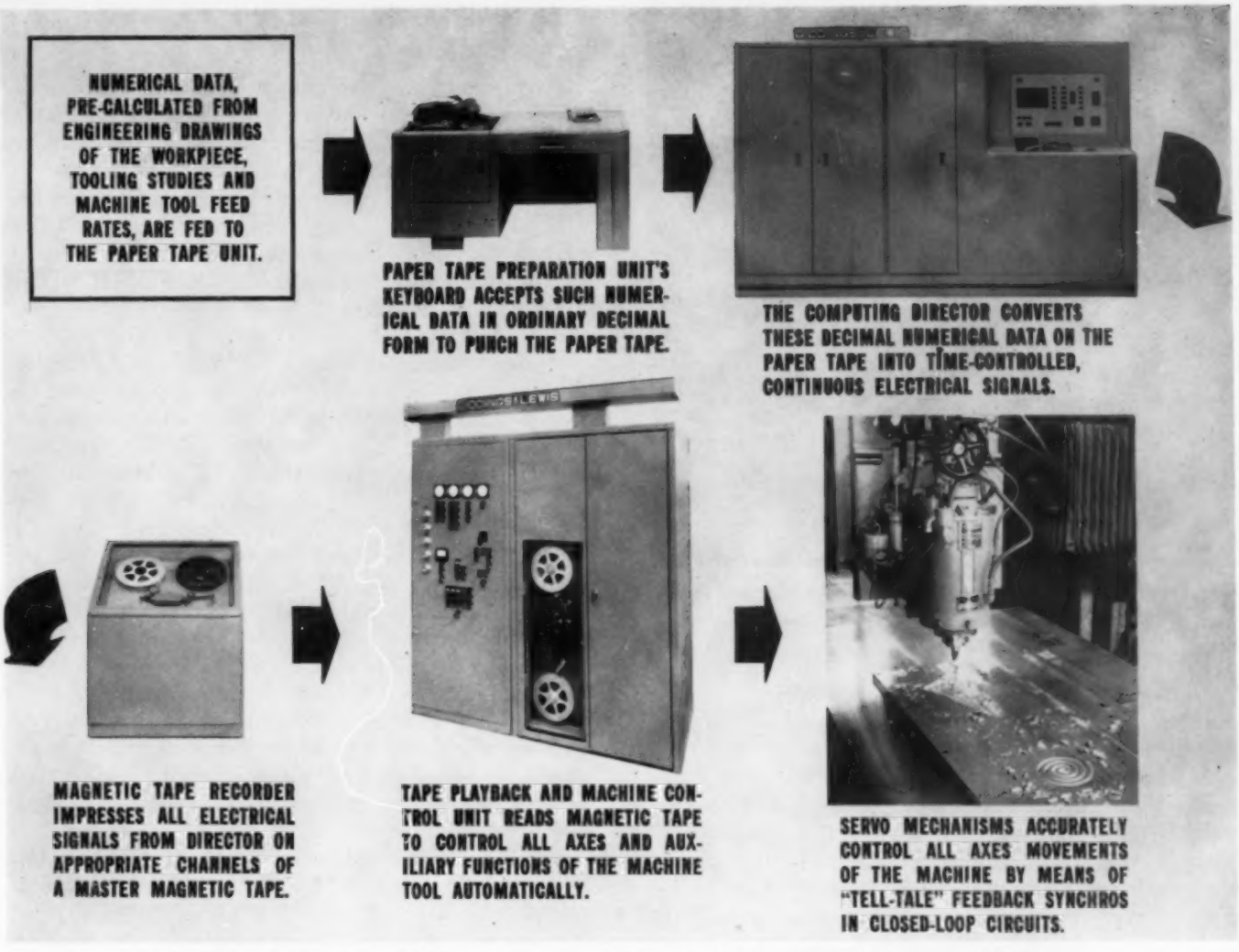
An improvement in conventional dust collectors of the tubular cloth filter type, was made by charging the filter bags with a filter aid which precoats the filtering surface and provides a highly efficient matrix upon which the fine particles of atmospheric dust and tarry matter are collected. One application of this filter aid is said to last two to three years. The only maintenance required is to shake out the spent filter aid and accumulated dust from the bags. Applications of this process are ventilation and cooling of electrical control rooms, cleaning of motors, etc.

Aluminum is a material which has had relatively little strength under high temperatures. Two new aluminum alloys were announced during the year, one of which has excellent properties at temperatures up to 600 F, the second at temperatures up to 400 F.

For the first time diamonds were made artificially by man. Primary application for these will be in industrial uses such as cutting and polishing. Diamonds were made by subjecting carbon to pressures up to 800,000 psi for long periods of time. Another unit in

A spray panel, mounted on gear housing, is a sound method for spraying lubricant on pressure side of gear teeth.




NUMERICAL DATA, PRE-CALCULATED FROM ENGINEERING DRAWINGS OF THE WORKPIECE, TOOLING STUDIES AND MACHINE TOOL FEED RATES, ARE FED TO THE PAPER TAPE UNIT.
PAPER TAPE PREPARATION UNIT'S KEYBOARD ACCEPTS SUCH NUMERICAL DATA IN ORDINARY DECIMAL FORM TO PUNCH THE PAPER TAPE.
THE COMPUTING DIRECTOR CONVERTS THESE DECIMAL NUMERICAL DATA ON THE PAPER TAPE INTO TIME-CONTROLLED, CONTINUOUS ELECTRICAL SIGNALS.
MAGNETIC TAPE RECORDER IMPRESSES ALL ELECTRICAL SIGNALS FROM DIRECTOR ON APPROPRIATE CHANNELS OF A MASTER MAGNETIC TAPE.
TAPE PLAYBACK AND MACHINE CONTROL UNIT READS MAGNETIC TAPE TO CONTROL ALL AXES AND AUXILIARY FUNCTIONS OF THE MACHINE TOOL AUTOMATICALLY.
SERVO MECHANISMS ACCURATELY CONTROL ALL AXES MOVEMENTS OF THE MACHINE BY MEANS OF "TELL-TALE" FEEDBACK SYNCHROS IN CLOSED-LOOP CIRCUITS.

Machine tools are being designed for automatic operation, particularly for repetitive items.

which they are made applies pressures up to 1,500,000 psi at temperatures of about 5000 F.

A new technique in corrosion control is the use of vapor-phase inhibitors. These are organic chemicals which evaporate slowly in a confined space and deposit the active rust-inhibiting agent on the surfaces which are to be protected. One of the most promising uses is in the packaging of porous metals or parts. It is believed that the material forms a thin chemical film on the steel surface which regulates the electric potential and prevents the movement of the rust forming ions. An advantage of vapor-type inhibitors is that the vapor diffuses to all exposed surfaces.

Another approach to the protection of equipment which has to operate under high temperature and corrosive conditions is the use of plastic dispersions. They are chemically inert, temperature resistant materials which can be applied by spraying, dipping or spreading on metallic and non-metallic surfaces. The dispersions are compounded from fluoro-carbon polymers.

One company which handles a great deal of highly corrosive liquids switched completely from metal to polyvinyl chloride plastic piping for all services, and drastically cut their heavy piping maintenance cost. This piping handles sulphuric acid, nitric acid, muriatic acid, phosphoric acid and glacial acetic acid. An advantage of this type of material is that no painting is required. The plastic pipe has no scale and the materials handled are well protected against contamination.

The use of paints rich in zinc dust content helps in rust prevention, since such paints give a certain amount of cathodic protection. Although not as protective as galvanizing, the material can be installed on an existing structure under ordinary painting conditions.

The largest universal testing machine in the world was put into operation at the Fritz Engineering Laboratories of Lehigh University. This is a 5,000,000-lb machine which can apply both tension and compression loads in this range. Distance between the screws is unusually wide, and pieces up to almost 10 ft wide can be handled.

A new basis for the separation and purification of mixtures of gases or liquids has been developed through the use of two selective adsorbents. The unique feature of these new adsorbents is that they separate mixtures or gases or liquids on the basis of the difference in molecule size. Up to the present time, differences in boiling points have been the primary factor in selective adsorption. These new materials are man-made crystalline zeolites. In addition to separation, the sieves can be used for drying and purification of gases. They can also absorb water at temper-

Carbon dioxide has been developed for use in gas-shielded metal arc welding processes.

atures up to 212 F, making it unnecessary to cool the gas before drying. The new adsorbents can be easily regenerated by combination of heating and purging, and thus can be used over and over again.

A large pipe mill in the southwest found that all grease lubrication on its mills can be done with two weights of a multi-purpose grease. The grease combines lithium with 12-hydroxystearic acid (hydrogenated castor oil). Points which formerly had to be checked every three weeks are now checked at periods up to three months. No bearing failures have occurred since changing to the grease. With the exception of three automatic systems, all connections are serviced with pressure guns.

Experiences with bearings on a 56-in. hot strip mill shows that a molybdenum disulphide impregnated fabric bearing used on the scalebreaker lasted much longer than the regular molded phenolic resin bearings previously used in this installation.

One company is marketing a spray valve panel designed to spray-lubricate gears. The self-contained panels are fastened to the gear housings or frame work, and spray the lubricant directly on the pressure side of the gear teeth. These panels feature stainless steel spray valves with built-in nozzles. Central pumping units deliver gear lubricant at regular intervals through the valves.

Tests by the Board of Fire Underwriters gave a synthetic hydraulic fluid a fire hazard rating of 2-3. This is much less flammable than petroleum oil. Lubricity is equivalent to petroleum oils.

This new fluid has been used successfully in automatic control regulators. In one case, the fluid proved self-extinguishing when broken lines poured 350 gallons of it into flames which were hot enough to melt the system's brass fittings.

A number of new welding techniques were demonstrated during the year, including powdered iron coatings for rod, carbon dioxide atmospheric welding and several new automatic welding machines. Iron powder has been incorporated into the coating of low-hydrogen electrodes, giving higher deposition rates with both a-c and d-c current.

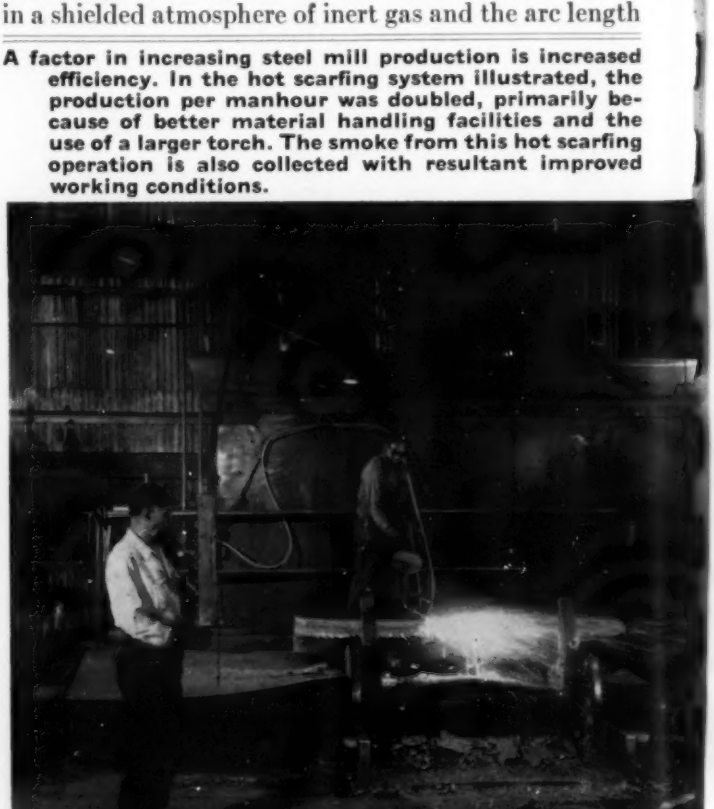
Another welding development brings equipment which uses carbon dioxide gas instead of helium or argon for the inert shielding atmosphere. Gas costs are cut about two-thirds with this development. Two companies are marketing straight carbon dioxide gas and a third uses both carbon dioxide and argon. Straight carbon dioxide is particularly effective for use with carbon steels, but the combination gas is better fitted for stainless and other alloy steels which tend to oxidize.

A new automatic submerged arc welding process preheats the electrode almost to its melting point before it enters the arc. Thus, the arc does not have to supply the sensible heat required to bring the metal to the melting point. Experiments have shown that the deposition rate at high current density is directly proportional to the length of the electrode wire from the contact shoe to the arc. Therefore, a sensitive relay is used to control the length of the electrode projecting from the nozzle. It is claimed that the method will deposit up to 100 lb of weld metal per hr with a current of 1000 amp. Much less base metal is melted by the method.

A new universal arc welder put on the market gives a choice of either a-c or d-c welding current. It is designed for every type of manual welding application. Models available run in capacities from 200 to 500-amp.

A welding process using an inert-gas shielded arc, has been specially developed for the manufacture of welded stainless steel and high alloy tubing and pipe. Heat is generated by an arc struck between a non-consumable tungsten electrode and the work. This arc occurs in a shielded atmosphere of inert gas and the arc length

A factor in increasing steel mill production is increased efficiency. In the hot scarfing system illustrated, the production per manhour was doubled, primarily because of better material handling facilities and the use of a larger torch. The smoke from this hot scarfing operation is also collected with resultant improved working conditions.



is automatically maintained. No additional metal is required, and the weld gives complete fusion of the butted edges of the strip. Therefore, the weld has the same composition as the parent metal and is free from inclusions, oxides and similar defects. Close control of the weld beads is obtained, so that it is possible to keep the inside of the tubes very smooth.

A recently introduced resistance welder fabricates wide wire mesh at high speeds. The unit can produce mesh in widths up to 13 ft from continuous coils of No. 4 to No. 14 gage wire. The unit welds 60 cross wires every minute to as many as 79 longitudinal wires. It consists of five basic components: a longitudinal wire straightener, a multiple cross wire feed, straightener and cutoff, resistance welding crosshead, a slitter and coiler.

Radioactive cobalt 60 is being used in an inspection unit for checking flaws and welds in metals. Compared with high voltage x-ray equipment, the unit has lower cost, less shielding, greater mobility. It is capable of radiographing steel up to 7 in. thick.

There has been increased emphasis on the operation of complex machine tools without human guidance through newly developed automatic systems. One of these combines an electronic brain and magnetic memory functions to produce duplicate precision parts directly from blueprint dimensions. This unit operates on a magnetic tape recording. It is also possible to include on the tape verbal orders which will point out to the machine attendant such pending operations as tool changes, inspection stops and completion of machining cycles.

This unit consists of four individual components: (1) the paper tape preparation unit which punches a master numerical tape with previously calculated information from the blueprint, tooling data, and machine feed and speed rates; (2) the electronic director, which converts this information into electrical command signals impressed on appropriate parallel channels of a magnetic tape; (3) the control unit which reads the commands off the magnetic tape and sends correct electrical control signals to the machine, and (4) the electro-mechanical apparatus which controls the machine response to the command signals on the magnetic tape. The first two steps. paper tape preparation and electronic-director portions are independent of the machine. One advantage is that information on skilled operations can be stored in the system. Machine tools such as horizontal boring, drilling and milling machines, planer type milling machines, and vertical boring mills as well as skin milling machines are being offered with the system. This system can automatically control as many as five simultaneous machine motions or tool heads, and 22 separate auxiliary machine parts, including lubrication, coolant and chip conveyor systems.

The punched tape principle of automatic operation was applied by another manufacturer to a precision boring machine used in the production of instrument gear trains. Instructions in this system are punched on the tape by a perforating machine similar to a typewriter. Electronic signals from the tape regulate the linear travel of the boring machine's hydraulic cross slide as well as the rotary motion of a specially-designed holding fixture mounted on the cross slide.

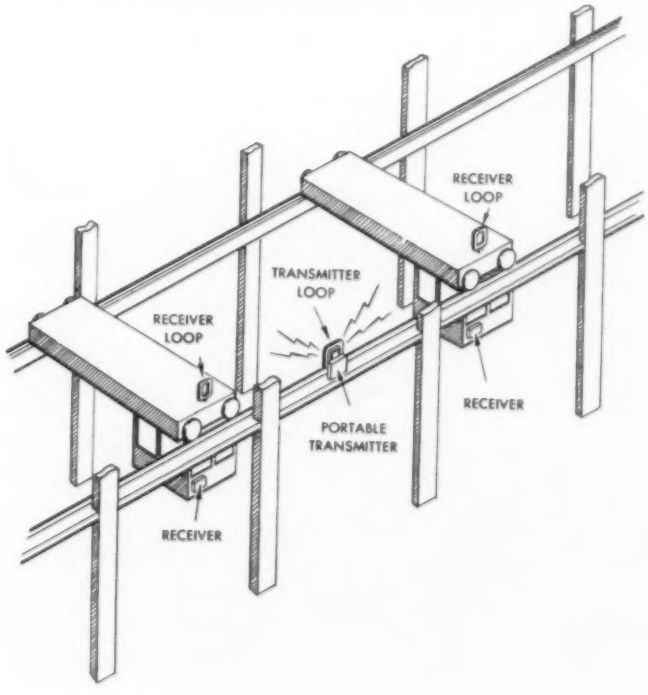
A magnetic flow meter has been developed which requires no restriction in the pipeline, thus allowing free flow of water-borne solids. The meter consists of a non-magnetic flow tube with an insulating liner containing flush-mounted metallic electrodes and surrounded by an a-c electrode magnet. When a conductive liquid passes trrough the tube, an alternating voltage is set up between the electrodes which varies linearly in proportion to the volume rate of flow. Wires from the electrodes transmit this voltage output to a recorder graduated to show flow. The gage can be used to measure density or to determine mass flow of water-borne solids. It is particularly adaptable to handling such items as ore slurries and sludges.

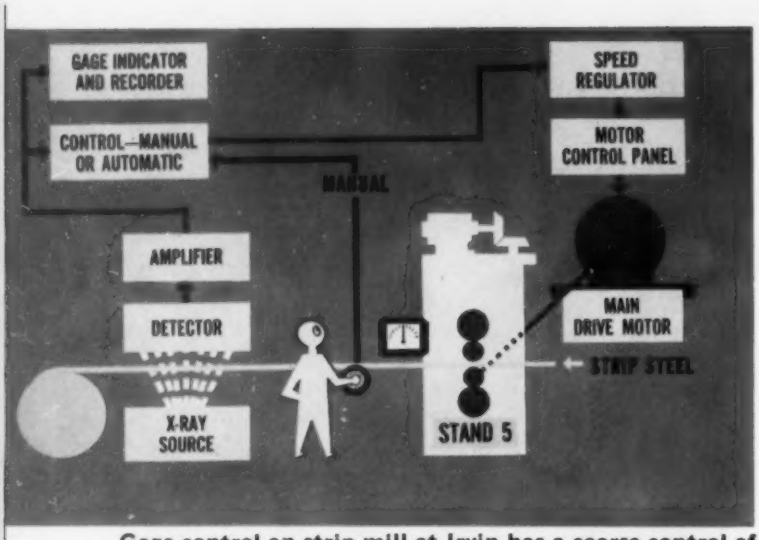
New inter-office communication has been installed which transmits photographs, letters, drawings or the human voice. In the process, copy is wrapped around a drum and, as the drum revolves, a photoelectric cell scans the copy at a rate of 2400 impulses a second. The cell transposes the varying degrees of darkness on the copy to a correspondingly varied intensity of sound which goes over a direct wire to the receiver. At the receiving end, the sound is transposed back into electrical impulses which are carried to a thin steel plate called a printer bar. By an electrolytic process a print is made on the paper.

ELECTRICAL

Perhaps no industry is finding more increased demands for its product than the electric utilities which are expanding at a rapid rate. Estimates of future power requirements, though varying widely, are enormous. The Federal Power Commission estimates that electric power requirements from utilities in 1980 will be 1,196,000,000,000 kwhr compared with 545,000,000,-

An electronic system can be used on cranes to prevent them from going by a predetermined point.





Gage control on strip mill at Irvin has a coarse control of strip gage through operation of the screwdown on stand No. 1, and a vernier or fine control of strip gage through adjustments on the speed of the main drive motor on stand No. 5.

000 kwhr in 1955. Some sources see a possible doubling of this estimate. The Edison Electric Institute estimates that utility generating capacity in the U. S. will reach 138,000,000 kw by 1959. Capacity of utilities at the end of 1955 was estimated to be over 120,000,000 kw, an addition of 12,500,000 kw in 1955.

With the large increase in power generation, it is fortunate that there has been a decrease in the amount of coal needed to generate electricity. The best new plants will generate one kwhr from about ¾ lb of coal compared with the one lb which was needed in 1935.

Industrial requirements now account for about half of the nation's consumption of electricity. In 1953, the electrical energy requirements of industry reached what was then an all time high of 257,000,000,000 kwhr. In 1954 about 265,000,000,000 kwhr were used in spite of the industrial fall-off during the year. Of this amount the steel industry used about 12 per cent.

The steel industry is increasing its requirements of electricity appreciably. In 1950, 24,500,000,000 kwhr were used. In 1953, this had increased to 30,800,000,000 kwhr. In the next three years, new electric furnaces on order will consume more than 3,000,000,000 kwhr annually. It is estimated that by 1958 the steel industry will need 42,000,000,000 kwhr and by 1963, 61,000,000,000 kwhr.

Total electricity generated in 1955 was 623,000,000,000 kwhr, of which 78,000,000,000 kwhr were produced by railroad and industrial plants and the remaining 545,000,000,000 kwhr were produced by electric utilities.

Two 16,000-kw gas turbine-generator sets purchased in 1955 set a new high in ratings for this type of unit. They are scheduled for installation adjacent to a Mexican steel mill. Natural gas will be used as the fuel.

A large generator with a liquid-cooled stator is under construction. This is a 260,000-kva unit to be installed by an Ohio utility.

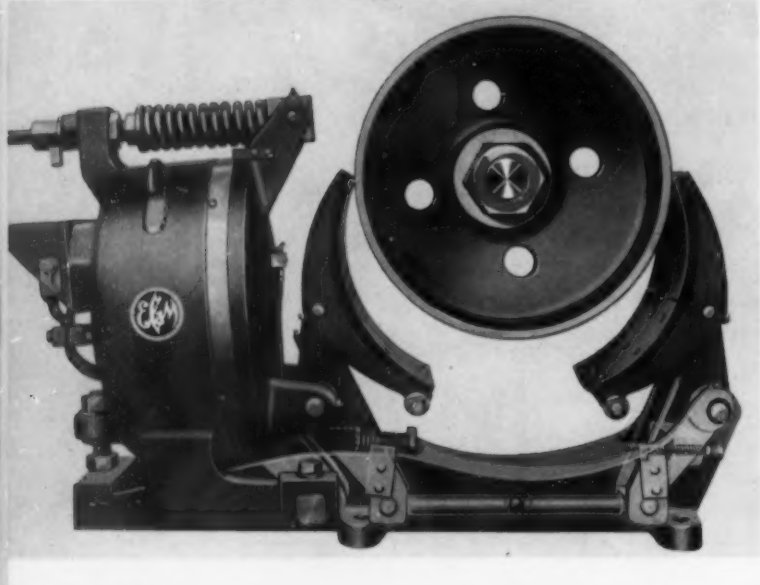
The largest reactor ever built was shipped during the year. It is a 56,000-kva, oil-immersed, current-limiting reactor which will be used as a tie between two 161-kv buses at a utility. The reactor is designed to withstand short circuit current of about 7200 amperes for five seconds.

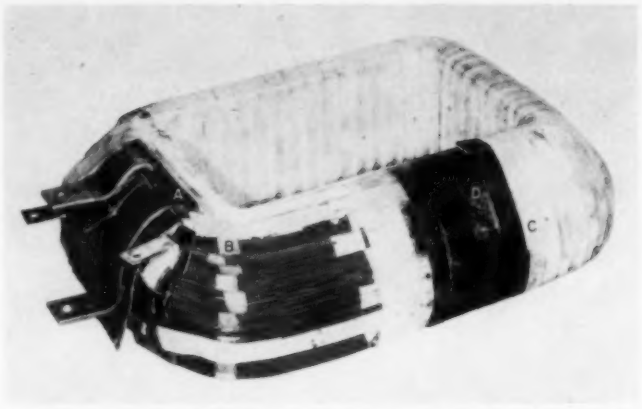
One manufacturer introduced a new isolated phase bus for connecting central station generators to high tension transformers. The new bus construction eliminates all of the linear gaskets formerly used, as well as the supporting ring gaskets and cover bolts.

An interesting application of power is used on a new high speed 23-stand, 3-strand rod mill which is being built for a steel plant in Pennsylvania. Maximum delivery speed of No. 5 rod will be 5,000 fpm. The ventilation of the main drive motors is rather novel. Two axial flow fans in the base of each motor force air through a removable air-to-water heat exchanger, through filters to remove carbon brush dust, and through the motor in an individual enclosed recirculating system which requires no pit under the floor. D-c power is supplied by metal-enclosed, pumpless rectifiers. Rectifier conversion equipment and rolling mill motors are factory packaged, eliminating the need for large air ducts, etc. Another unusual feature is that the motors are designed with normal WK^2 and operate with new combination magnetic amplifier-rotating speed regulators.

An interesting feature on the semi-continuous hot strip mill at McLouth Steel is the use of individual motor drives on each roll of the roughing mill approach table, on the front and rear mill tables, and the finishing mill approach tables. Tables of this type have normally been driven in sections from lineshafts, and set up maintenance and lubrication problems. The use of 146 individual adjustable-voltage roll drive motors has eliminated a great deal of this maintenance. An annual savings of $60,000 in lubrication costs have been estimated. Seventy-six of the motors on the roughing mill approach and front and rear mill tables are AISE No. 608 mill type motors, rated at 10 hp, 250 rpm, 230 volts and furnished with a single shaft extension and standard 550 volt armature to give low speed at 230 volts. The 70 motors on the finishing mill approach table are No. 606, 7½ hp, 230 volt, with 550-volt armatures. They are force-ventilated through an air duct built into the table base. Motors are mounted on 2-ft

Several new brakes are now in production, built to AISE standards.





Mill motors were put on the market using Class H insulation in a number of the components.

centers and some modifications on the frame were made to allow this setting. Loss of a single motor or gear will no longer shutdown the mill. This roughing mill also has automatic preset screwdown control.

Three structural mills now under construction are being equipped with automatic preset screwdown control. Two of these mills are in England and will use control of the constant potential type. The third control of the variable voltage type, is to be installed on the new 44-in., universal, structural mill at Inland Steel's Indiana Harbor plant.

The new controls use schedule panels equipped with slider contacts for preselecting complete rolling schedules. Once the sliders are properly positioned for the desired mill settings, the operator presses a button once for each mill pass. Pressing the button actuates the horizontal, vertical and edger roll adjustment drives in unison, with automatic positioning controls stopping the adjustment to get the exact roll separation for the particular pass called for by the schedule panels. It is possible to schedule the control to handle virtually any size beam. Manual control of any or all roll adjustment movement is also instantly available to the operator by means of a master switch which cuts out the automatic positioning control.

The trend towards greater mechanization and more automatic means of production is resulting in an increasing demand for direct-current drives. This is a reversal of an earlier trend and is due to increased demand for adjustable speed, which is so necessary in most continuous processing lines. Purchases of direct-current motors in the one to 200-hp range have increased 85 per cent since the end of World War II, compared with a 20 per cent increase in the purchases of all motors within that same power range in the same period.

One manufacturer has developed a precise adjustable speed drive which can be coupled or belted to an existing motor to get a speed control of plus or minus two per cent for use in units such as fans, pumps and compressors. It is also designed to handle constant torque loads such as conveyors, machine tools and many other applications.

This system consists of a speed drive composed of a ring member connected to the input shaft and a magnet member which is mounted on the output shaft. There is no solid physical connection between the ring and magnet member. The ring member is driven at constant speed and the magnet member is excited by d-c from the control, setting up a magnetic attraction between the two rotating members. More field excitation increases the magnetic force, so that the magnet member speed increases.

One company is offering an improved line of d-c armored mill motors which utilize class H materials. This insulation will withstand temperatures up to 180 C, and in normal duty should virtually eliminate insulation failure. A specially developed silicone varnish is also used. Class H insulation has been adapted to three main sections of the motor: the field coils, the armature coils and the main area of the armature insulation. Silicone treated mica mat is used on the commutating and exciting field coils and on armature coils. Class H insulated coils may be interchanged with class B coiled in older motors of the line.

The National Electrical Manufacturers' Association (NEMA) issued a new standard for d-c motors and generators No. MG1-1955. These new standards cover what are known as general-purpose integral horsepower motors up to 200 hp and generators up to 150 kw, and have been set up as a suggested standard for future design. Among the new features in the standard is a definition which states that "an industrial direct-current motor is a direct-current drip-proof motor having a continuous rating and designed, listed and offered in standard ratings with standard operating characteristics and mechanical construction for use under usual service conditions without restriction to a particular application or type of applications."

One of the important features of this definition is that it specifies a drip-proof enclosure compared with the open closure of the general purpose motor definition. Another change is that standard voltages for integral horsepower d-c motors had previously been 115 and 230 volts. With the present trend towards locating the power source closer to the motor resulting in lower line drops, the new standard suggests that motors be

Automatic positioning screwdown controller will be used on a structural "H"-beam mill.

rated at 120 and 240 volts; 120 volts is standard for motors only up to 10 horsepower.

The number of ratings is reduced from the previous 502 to a new list of 156 speed and hp ratings for the motors. The new standard does not classify the ratings as constant speed and adjustable speed but groups them all together. New motor ratings have a continuous 60 C rise horsepower rating at base speed with a service factor of 1.15. Previously, open adjustable speed motors had no service factor at base speed.

Perhaps one of the most important factors of the new standard is that which establishes class B insulation with a temperature rise of 60 C for industrial (drip-proof) motors and generators. The new standards should enable manufacturers to make smaller, lighter motors with faster response.

The standardization work on the additional frame sizes in the AISE mill motor is essentially complete. The new ratings will be 275, 375 and 500 hp for the 1-hr, totally enclosed, 75 C rise ratings.

Metallic rectifiers made from germanium crystals are becoming available in much larger sizes than previously. The best field of application seems to be in units with d-c voltages up to 70 volts. The advantage of this material over selenium or copper oxide is higher efficiency; losses are claimed to be less than half the losses of other types. Germanium units rated at 6000 amperes and 24 volts d-c have been installed on an anodizing line. Other units have been installed on existing electrolytic tinning lines.

Additional manufacturers have developed mill motor brakes which meet the new AISE standards for d-c brakes. These have many features which will make them popular with operating and maintenance personnel, such as linings which can be removed readily without removing the brake shoe assembly, armature gap indicators which show changes in the armature gap due to lining wear, and which give a visible indication to adjust for wear. In one design, the magnet coil is a completely sealed unit, excluding dust, oil and moisture.

Another line of brakes built to the AISE specification features a magnet case which can be quickly removed without disturbing the brake adjustments. This design has complete lubrication of all bearings, accurate braking torque adjustments with a single bronze adjusting nut, single point brake shoe clearance adjustment, and an armature air-gap adjustment which requires the use of only one wrench and utilizes a stainless steel bushing and nut assembly for greater accuracy. No levers, rods or other parts pass over the top of the brake wheel.

Developments in automatic processing operations are reflected in many control systems which are a requirement of such operations. Automatic gage control is one of the significant developments in tandem cold reduction mills. One system was demonstrated on the 5-stand mill at the Irvin Works late in the year. This controls steel strip thickness to closer tolerances than previously obtainable.

For several years this mill had an X-ray gage between the last stand and the winding reel. The new control has two sections, a coarse system which utilizes an X-ray gage between stands No. 1 and 2 with a regulating system which operates screwdown motors on stand No. 1, and a vernier system which uses an X-ray gage at stand No. 5 with a regulating system which varies stand drive motor speed to effect gage control. The system uses transistors and magnetic amplifiers for quick response. Because of the small number of moving parts, these components should have relatively-low maintenance.

In the operation of the coarse system, thickness as measured between stands No. 1 and 2 by an X-ray gage is compared with the required thickness set as a reference signal; the difference between actual and required thickness is shown as a deviation signal. This signal is fed into a transistor amplifier system which develops the direction of the error and passes the signal to a magnetic amplifier system. A definite interval is provided between the time impulses to permit the strip to get from the rolls of stand No. 1 to the X-ray gage position before the automatic control makes any further correction on the screwdown motors. This time or interval varies with strip speed. A somewhat similar scheme is used for the vernier system.

Many applications are being found for transistors and magnetic amplifiers in various control systems. Since response of magnetic amplifiers increases with the frequency, special power supplies are in common use to get quicker response. However, transistors can often give the desired high frequency without special power supplies. Thus, magnetic-amplifier circuits with extremely high rates of response and of small size are possible. Transistors also make possible the application of high efficiency d-c transformers by converting the current to a square wave to change the voltage; then, by rectification, the current is changed back into d-c. Overall efficiencies for small wattage circuits are about 90 per cent. Transistors can also be used as switches or relays. Combinations of transistors and magnetic amplifiers can be used to create time delays with an accuracy within one cycle of the basic frequency.

A very interesting development during the year is the result of a long term research and development program in solid-state phenomena. These are systems which consist of static switching circuits which can be used for industrial control, and which are essentially relay systems with no moving parts. The systems are essentially digital devices, but can be combined with analog devices when the control problem requires it. Elements used in circuits include magnetic amplifiers, transistors, and static rectifiers. Functions of these units are such that it is believed they can be developed to give complete control of machine operations. An application on the loading mechanism for a billet furnace is being considered.

A novel control for crop and cobble shears is being built for a rod mill in the East. Shear knives are controlled photoelectrically at starting, accelerate to the speed of the hot billet in 180 degrees, then decelerate and stop preparatory to the next operation. The 35-hp, 575-rpm motor must be up to speed at about 2½ revolutions. To obtain this, the control uses motor field forcing and magnetic amplifier speed regulation with current limit acceleration control.

One control manufacturer is offering a counter-emf plugging system for the protection of direct-current motors on reversing mill drives, crane drives, and similar applications. Operation of this system is completely independent of variations in line voltage. It incorporates a small rectifier and mill duty relay which requires no field adjustment. The relay, which is provided with a single shunt-wound operating coil, is designed to pick up and close on low voltage, permitting full plugging protection down to approximately 10 per cent of maximum rated speed. When the motor is started from rest in either direction, the current blocking action of the rectifier permits the plugging contactor to close instantly. This same rectifier prevents closure of the plugging contactor when reverse power is applied to the motor during plugging. Relay dropout allows the plugging contactor to close as the motor stops. A two-step counter-emf plugging system controller has also been designed for use when heavy inertia loads are involved, such as on ore bridge trolleys and large ladle crane bridge motions.

A new tension regulator for sendzimir mills uses magnetic amplifiers to give more constant tension on the strip, resulting in faster acceleration and deceleration. A pattern field in the magnetic amplifier regulator is excited in proportion to the tension setting made by the operator. A second deflection winding receives a signal indicating the actual tension on the strip. The fields of these two windings are in opposition, and any differences between strengths of the pattern and deflection fields gives a signal to the reel motor to increase or decrease the tension. If the tension is correct, the two fields cancel each other, except for a small steady-state signal required to maintain the desired strip tension.

The deflection winding receives its intelligence as to tension through a roll on the mill so arranged that it is deflected in proportion to strip tension. This deflection is transmitted through a mechanical system to move a magnetic pick-up unit whose output is fed to the deflection winding of the magnetic amplifier. This regulator has been applied on a 37-in. reversing mill to replace a system that was hydraulically and electrically controlled.

A new electronic system gives automatic opening and closing of soaking pit covers. The equipment will select and operate up to 50 separate covers from moving or stationary locations. The selection can be made either by the pit crane operator or from a monitor on the floor. If the selection is made from the floor location, the switching signal is "stored" by the equipment. When ready for his operation, the crane man controls the opening and closing of the selected pit covers by an operating button. A time-saving feature is that the pit cover can be opening while the crane is approaching the pit.

One leading brush manufacturer introduced a new series of brush grades during the year designed to combine high commutating ability with long life. One grade is a low contact drop brush which is available for a variety of equipment over a broad voltage range. It is especially desirable for enclosed mill type motors.

Another grade is specifically designed for operation on machines which have class H (silicone) insulation. This grade does not show the bad dusting characteristics which some previous brushes had in silicone motor applications. Another brush grade is especially recommended for applications where heavy load swings required exceptional brush characteristics to give smooth trouble-free operation and peak commutation under all service conditions.

Aluminum dry cell batteries with a long shelf life have been developed, although not yet put into a production stage. The use of aluminum has previously not been economical because the aluminum can (anode) of the battery either became perforated or an oxide film was built up which increased the internal resistance to a point where the battery no longer was usable. By the use of suitable inhibitors, the oxide formation has been reduced without causing perforations in the can.

A new high strength aluminum alloy, designed specifically to meet the needs of the electrical industry, is a magnesium silicide alloy which can be used for a light weight, high strength conductor. It has been approved for busway applications by a number of manufacturers. Mechanical properties approach that of copper, and conductivity is from 55 to 60 per cent that of copper.

An interesting development which has helped in resistance heating of steel blanks for rolling or forging is a deformable, electrically conductive material which can be used to obtain better contact between the contact piece of the resistance unit and the blank to be heated. The material is manufactured by sintering iron or metal powder into the form of plates.

A magnet wire uses a recent insulation development,

(*Continued on page 166*)

Television is being used more widely in steel plant operation. Operator is checking alinement of slabs on two ITV monitors.

ELECTRIC MOTOR DRIVES THREE HUNDRED HORSEPOWER AND OVER

APPLIED ROLLING MILLS IN THE IRON AND STEEL AND ALLIED INDUSTRIES DURING 1955

Item	Horsepower	Revolutions per minute	Volts	Frequency	Method of drive	Type of mill	Purchaser	Location	Manufacturer
1	②300	200/600	230	d-c	Geared	Aluminum sheet mill	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	Westinghouse
2	300	150/450	300	d-c	Geared	Aluminum cold mill	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	Westinghouse
3	300	150/450	300	d-c	Geared	Aluminum cold mill	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	Westinghouse
4	300	400/1000	600	d-c	Direct	Merchant mill	Northeastern Steel Corp.	Bridgeport, Conn.	Westinghouse
5	300	400/1000	600	d-c	Direct	Merchant mill	Northeastern Steel Corp.	Bridgeport, Conn.	Westinghouse
6	300	600	2300	60	Geared	Piercing mill	Babcock & Wilcox Co.	Beaver Falls, Pa.	Westinghouse
7	300	600	2300	60	Geared	Piercing mill	Babcock & Wilcox Co.	Beaver Falls, Pa.	Westinghouse
8	300	450/1350	250	d-c	Direct	4-High aluminum finishing mill	Sheet Aluminum Division of Mueller Brass Co.	Jackson, Mich.	Westinghouse
9	300	100/200	600	d-c	Geared	Rod mill No. 1 stand	Keystone Steel and Wire Co.	Peoria, Ill.	Elliott
10	300	500/800	250	d-c	Geared	Reversing hot mill	National Lead Co.	Granite City, Ill.	Elliott
11	300	400/1200	250	d-c	Geared	Reversing cold mill	Cold Metal Products of California	Los Angeles, Calif.	Elliott
12	300	150/450	250	d-c	Geared	2 Stand aluminum cold strip mill reel	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	General Electric
13	300	150/450	250	d-c	Geared	2 Stand aluminum cold strip mill reel	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	General Electric
14	350	250/1300	750	d-c	Direct	2-Stand temper mill reel	Youngstown Sheet and Tube Co.	Indiana Harbor, Ind.	General Electric
15	350	250/1300	750	d-c	Direct	2-Stand temper mill reel	Youngstown Sheet and Tube Co.	Indiana Harbor, Ind.	General Electric
16	350	575/1650	250	d-c	Geared	60-in. Foil mill	Cochran Foil Products Co.	Louisville, Ky.	Reliance Electric and Engineering
17	350	575/1650	250	d-c	Geared	60-in. Foil mill	Cochran Foil Products Co.	Louisville, Ky.	Reliance Electric and Engineering
18	350	400/800	250	d-c	Geared	Sendzimir reversing cold mill	Somers Brass Co.	Waterbury, Conn.	Elliott
19	350	400/800	250	d-c	Geared	Sendzimir reversing cold mill	Somers Brass Co	Waterbury, Conn.	Elliott
20	350	300/1030	2500	d-c	Geared	32-in. Temper mill reel	Alan Wood Steel Co.	Conshohocken, Pa.	Westinghouse
21	375(Fr 622)	360/600	230	d-c	Geared	Pickle line processor No. 1	Bethlehem Steel Co.	Sparrows Point, Md.	Westinghouse
22	375(Fr 622)	360/600	230	d-c	Geared	Pickle line processor No. 2	Bethlehem Steel Co.	Sparrows Point, Md.	Westinghouse
23	375	425/1200	250	d-c	Geared	Reversing hot mill	U. S. Steel Corp.	Pittsburgh, Pa.	Elliott
24	400	600/750	350	d-c	Direct	Tension device	Bethlehem Steel Co.	Sparrows Point, Md.	Westinghouse
25	①②400	800	325	d-c	Direct	Skin pass mill	Bethlehem Steel Co.	Sparrows Point, Md.	Westinghouse
26	①②400	800	325	d-c	Direct	Skin pass mill	Bethlehem Steel Co.	Sparrows Point, Md.	Westinghouse
27	②400	300/900	250	d-c	Geared	4-Stand tandem cold mill reel	Chase Brass and Copper Co.	Cleveland, Ohio	Westinghouse
28	400	200/600	300	d-c	Geared	Aluminum cold mill	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	Westinghouse
29	400	200/600	300	d-c	Geared	Seamless tube mill	Youngstown Sheet and Tube Co.	Indiana Harbor, Ind.	Westinghouse
30	†400	514	2300	60	Geared	Seamless tube mill	Youngstown Sheet and Tube Co.	Indiana Harbor, Ind.	Westinghouse
31	†400	514	2300	60	Geared	Seamless tube mill	Youngstown Sheet and Tube Co.	Indiana Harbor, Ind.	Westinghouse
32	†400	514	2300	60	Geared	Seamless tube mill	Youngstown Sheet and Tube Co.	Indiana Harbor, Ind.	Westinghouse
33	†400	514	2300	60	Geared	Seamless tube mill	Youngstown Sheet and Tube Co.	Indiana Harbor, Ind.	Westinghouse
34	400	720	2300	60	Geared	Piercing mill	Babcock & Wilcox Co.	Beaver Falls, Pa.	Westinghouse
35	400	500/1000	600	d-c	Direct	Temper mill	Wheeling Steel Corp	Yorkville, Ohio	Westinghouse
36	①400	500/1000	600	d-c	Geared	Temper mill	Wheeling Steel Corp.	Yorkville, Ohio	Westinghouse
37	①400	500/1000	600	d-c	Geared	Temper mill	Wheeling Steel Corp.	Yorkville, Ohio	Westinghouse
38	400	720	4000	60	Geared	Reeler	Mannesmann Tube Co.	Sault Ste. Marie, Canada	General Electric
39	400	720	4000	60	Geared	Reeler	Mannesmann Tube Co.	Sault Ste. Marie, Canada	General Electric
40	400	720	4000	60	Geared	Reeler	Mannesmann Tube Co.	Sault Ste. Marie, Canada	General Electric
41	400	720	4000	60	Geared	Reeler	Mannesmann Tube Co.	Sault Ste. Marie, Canada	General Electric
42	400	690/1380	250	d-c	Geared	Wheel mill edger	Armco Steel Corp.	Butler, Pa.	General Electric
43	400	690/1380	250	d-c	Geared	Wheel mill edger	Armco Steel Corp.	Butler, Pa.	General Electric
44	400	400/1200	750	d-c	Geared	3-Strand rod and merchant mill, stand No. 3	Atlantic Steel Co.	Atlanta, Ga.	General Electric
45	400	400/1200	700	d-c	Geared	3-Strand rod and merchant mill, stand No. 4	Atlantic Steel Co.	Atlanta, Ga.	General Electric
46	400	400/1200	700	d-c	Geared	3-Strand rod and merchant mill, stand No. 5	Atlantic Steel Co.	Atlanta, Ga.	General Electric
47	400	400/1200	700	d-c	Geared	3-Strand rod and merchant mill, stand No. 6	Atlantic Steel Co.	Atlanta, Ga.	General Electric
48	400	400/1200	700	d-c	Geared	3-Strand rod and merchant mill, stand No. 7	Atlantic Steel Co.	Atlanta, Ga.	General Electric
49	400	400/1200	250	d-c	Geared	6 and 17 x 12-in 4-High non-reversing rolling mill	Simonds Saw and Steel Co.	Lockport, N. Y.	Reliance Electric and Engineering
50	①400	500/1000	750	d-c	Direct	Temper mill entry puller	Weirton Steel Co.	Weirton, W. Va.	General Electric
51	①400	500/1000	750	d-c	Direct	Temper mill entry puller	Weirton Steel Co.	Weirton, W. Va.	General Electric
52	400	500/100	750	d-c	Direct	Temper mill bottom delivery puller	Weirton Steel Co.	Weirton, W. Va.	General Electric
53	400	200/600	250	d-c	Geared	2-Stand aluminum cold strip mill reel	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	General Electric
54	400	200/600	250	d-c	Geared	2-Stand aluminum cold strip mill reel	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	General Electric
55	450	450/1350	250	d-c	Geared	60-in Foil mill	Johnson Tin Foil and Metal Co.	St. Louis, Mo.	Reliance Electric and Engineering
56	450	450/1350	250	d-c	Geared	60-in. Foil mill	Cochran Foil Products Co.	Louisville, Ky.	Reliance Electric and Engineering
57	500	225/675	250	d-c	Geared	Aluminum sheet mill	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	Westinghouse
58	500(Fr 624)	340/680	230	d-c	Direct	Slab shear	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	Westinghouse
59	500(Fr 624)	340/680	230	d-c	Direct	Slab shear	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	Westinghouse
60	500	400/800	600	d-c	Geared	Merchant mill	Northeastern Steel Corp.	Bridgeport, Conn.	Westinghouse
61	†500	360	440	60	Geared	Hot strip mill rougher scalebreaker	Jones and Laughlin Steel Corp.	Aliquippa, Pa.	Westinghouse
62	†500	360	440	60	Geared	Hot strip mill rougher scalebreaker	Jones and Laughlin Steel Corp.	Aliquippa, Pa.	Westinghouse
63	500	375/750	230/460	d-c	Geared	Shear drive	Inland Steel Co.	Indiana Harbor, Ind.	Westinghouse
64	500	375/750	230/460	d-c	Geared	Shear drive	Inland Steel Co.	Indiana Harbor, Ind.	Westinghouse
65	500	375/750	230/460	d-c	Geared	Shear drive	Inland Steel Co.	Indiana Harbor, Ind.	Westinghouse
66	500	300/600	600	d-c	Direct	Foil mill	Alcoa	Davenport, Iowa	Westinghouse
67	500	350/1130	690	d-c	Geared	48-in. Skin pass mill reel	Altos Hornos	Bilboa, Spain	General Electric
68	500	350/1040	700	d-c	Geared	3-Strand rod and merchant mill, stands No. 1 and 2	Atlantic Steel Co.	Atlanta, Ga.	General Electric
69	500	350/1040	700	d-c	Geared	3-Strand rod and merchant mill, stand No. 8	Atlantic Steel Co.	Atlanta, Ga.	General Electric
70	500	250/1040	700	d-c	Geared	3-Strand rod and merchant mill, stand No. 9	Atlantic Steel Co.	Atlanta, Ga.	General Electric
71	500	350/700	600	d-c	Direct	Sendzimir mill	Bridgeport Brass Co.	Bridgeport, Conn.	General Electric
72	①500	250/400	600	d-c	Direct	2-Stand temper mill, stand No. 1	Bethlehem Steel Co.	Sparrows Point, Md.	General Electric
73	①500	250/400	600	d-c	Direct	2-Stand temper mill, stand No. 1	Bethlehem Steel Co.	Sparrows Point, Md.	General Electric

*Indicates synchronous motor. †Induction motor. ①Twin motor drive. ②Double armature. ③Triple armature. ④One-half double armature.

Item	Horsepower	Revolutions per minute	Volts	Frequency	Method of drive	Type of mill	Purchaser	Location	Manufacturer
74	①500	‡50/400	600	d-c	Direct	2-Stand temper mill, stand No. 1	Bethlehem Steel Co.	Sparrows Point, Md.	General Electric
75	①500	‡50/400	600	d-c	Direct	2-Stand temper mill, stand No. 1	Bethlehem Steel Co.	Sparrows Point, Md.	General Electric
76	500	175/350	600	d-c	Geared	Rod and merchant mill, stand No. 1	Crucible Steel Co.	Midland, Pa.	General Electric
77	500	175/350	600	d-c	Geared	Rod and merchant mill, stand No. 2	Crucible Steel Co.	Midland, Pa.	General Electric
78	500	300/900	600	d-c	Geared	Rod mill, stand No. 10	Keystone Steel and Wire Co.	Peoria, Ill.	Elliott
79	500	300/900	600	d-c	Geared	Rod mill, stand No. 11	Keystone Steel and Wire Co.	Peoria, Ill.	Elliott
80	500	300/900	600	d-c	Geared	Rod mill, stand No. 12	Keystone Steel and Wire Co.	Peoria, Ill.	Elliott
81	500	300/900	600	d-c	Geared	Rod mill, stand No. 13	Keystone Steel and Wire Co.	Peoria, Ill.	Elliott
82	500	300/900	600	d-c	Geared	Rod mill, stand No. 14	Keystone Steel and Wire Co.	Peoria, Ill.	Elliott
83	500	300/900	600	d-c	Geared	Rod mill, stand No. 15	Keystone Steel and Wire Co.	Peoria, Ill.	Elliott
84	500	300/900	600	d-c	Geared	Rod mill, stand No. 16	Keystone Steel and Wire Co.	Peoria, Ill.	Elliott
85	500	300/900	600	d-c	Geared	Rod mill, stand No. 17	Keystone Steel and Wire Co.	Peoria, Ill.	Elliott
86	500	500/980	‡50	d-c	Direct	Sendzimir reversing cold mill	Somers Brass Co.	Waterbury, Conn.	Elliott
87	*500	‡77	‡300	60	Direct	12-in. Intermediate mill, No. 2	U. S. Steel Co.	Joliet, Ill.	General Electric
88	500	400/1050	600	d-c	Geared	Reversing hot mill	U. S. Steel Corp.	Pittsburgh, Pa.	Elliott
89	②500	300/1200	700	d-c	Geared	Tension reel	Alcoa	Alcoa, Tenn.	Allis-Chalmers
90	①500	575/1150	600	d-c	Geared	Temper mill	Jones & Laughlin Steel Corp.	Cleveland, Ohio	General Electric
91	①500	575/1150	600	d-c	Geared	Temper mill	Jones & Laughlin Steel Corp.	Cleveland, Ohio	General Electric
92	②534	‡50/950	300	d-c	Direct	Temper mill	Wheeling Steel Corp.	Yorkville, Ohio	Westinghouse
93	600	150/450	700	d-c	Geared	Edger	Armco Steel Corp.	Butler, Pa.	Westinghouse
94	600	‡50/900	600	d-c	Direct	Temper mill	Wheeling Steel Corp.	Yorkville, Ohio	Westinghouse
95	600	‡00/765	500	d-c	Geared	Merchant and bar mill finishing stand	Cia Fundidora de Chihuahua	Chihuahua, Mexico	Westinghouse
96	600	575/1150	500	d-c	Geared	Merchant and bar mill finishing stand	Cia Fundidora de Chihuahua	Chihuahua, Mexico	Westinghouse
97	600	125/400	600	d-c	Geared	Vertical edger	Empressa Nacional Siderurgica	Madrid, Spain	Westinghouse
98	600	720	400	d-c	Geared	Sizing mill	Mannesman Tube Co.	Sault Ste. Marie, Canada	General Electric
99	600	‡50/980	700	d-c	Geared	3-Strand rod and merchant mill, stand No. 10	Atlantic Steel Co.	Atlanta, Ga.	General Electric
100	600	350/980	700	d-c	Geared	3-Strand rod and merchant mill, stand No. 11	Atlantic Steel Co.	Atlanta, Ga.	General Electric
101	600	300/900	600	d-c	Direct	2-Stand temper mill reel	Bethlehem Steel Co.	Sparrows Point, Md.	General Electric
102	600	300/900	600	d-c	Direct	2-Stand temper mill reel	Bethlehem Steel Co.	Sparrows Point, Md.	General Electric
103	600	300/600	600	d-c	Geared	Rod and merchant mill, stand No. 3	Crucible Steel Co.	Midland, Pa.	General Electric
104	600	300/600	600	d-c	Geared	Rod and merchant mill, stand No. 4	Crucible Steel Co.	Midland, Pa.	General Electric
105	600	‡50/830	600	d-c	Geared	34-in. Reversing cold mill reel	Altos Hornos	Spain	General Electric
106	600	‡50/830	600	d-c	Geared	34-in. Reversing cold mill reel	Altos Hornos	Spain	General Electric
107	600	‡50/830	600	d-c	Geared	48-in. Reversing cold mill reel	Altos Hornos	Spain	General Electric
108	600	‡50/830	600	d-c	Geared	48-in. Reversing cold mill reel	Altos Hornos	Spain	General Electric
109	④600	‡00/800	375	d-c	Direct	Tandem cold mill reel	Breedband N.V.	Holland	General Electric
110	600	850/1100	600	d-c	Direct	2-Stand temper mill puller	Bethlehem Steel Co.	Sparrows Point, Md.	General Electric
111	600	850/1100	600	d-c	Direct	2-Stand temper mill puller	Bethlehem Steel Co.	Sparrows Point, Md.	General Electric
112	600	‡00/600	600	d-c	Geared	10-in. Bar mill	Rotary Electric Steel Co.	Detroit, Mich.	General Electric
113	700	300/885	‡50	d-c	Geared	Bar mill, stand No. 7, 8, 9	Republic Steel Corp.	Buffalo, N. Y.	General Electric
114	700	300/885	‡50	d-c	Geared	Bar mill, stand No. 12	Republic Steel Corp.	Buffalo, N. Y.	General Electric
115	700	300/600	600	d-c	Geared	Rod and merchant mill, stand No. 5	Crucible Steel Co.	Midland, Pa.	General Electric
116	700	300/600	600	d-c	Geared	Rod and merchant mill, stand No. 6	Crucible Steel Co.	Midland, Pa.	General Electric
117*	700	400	‡300	60	Geared	Seamless tube mill	Youngstown Sheet and Tube Co.	Indiana Harbor, Ind.	Westinghouse
118	750	300/600	600	d-c	Direct	Aluminum foil mill	Alcoa	Davenport, Iowa	General Electric
119	750	300/600	600	d-c	Direct	Aluminum foil mill	Alcoa	Davenport, Iowa	General Electric
120	750	300/600	600	d-c	Direct	Aluminum foil mill	Alcoa	Davenport, Iowa	General Electric
121	750	‡50/500	600	d-c	Direct	Single stand temper mill	Armco Steel Corp.	Middletown, Ohio	General Electric
122	②750	100/500	600	d-c	Direct	42-in. Tandem cold mill	Republic Steel Corp.	Warren, Ohio	General Electric
123	①②750	450/670/675	600	d-c	Direct	Skin pass mill tension device	Weirton Steel Co.	Weirton, W. Va.	Westinghouse
124	①②750	525/950	‡50	d-c	Direct	Temper mill tension device	Wheeling Steel Corp.	Yorkville, Ohio	Westinghouse
125	①750	850/1200	600	d-c	Geared	Skin pass mill	Weirton Steel Co.	Weirton, W. Va.	Westinghouse
126	①750	850/1200	600	d-c	Geared	Skin pass mill	Weirton Steel Co.	Weirton, W. Va.	Westinghouse
127	①②750	500/1000	600	d-c	Geared	Temper mill	Wheeling Steel Corp.	Yorkville, Ohio	Westinghouse
128	①②750	500/1000	600	d-c	Geared	Temper mill	Wheeling Steel Corp.	Yorkville, Ohio	Westinghouse
129	750	360/450	‡30	d-c	Geared	Hot strip mill rougher edger	Jones & Laughlin Steel Corp.	Aliquippa, Pa.	Westinghouse
130	750	450/900	600	d-c	Direct	Foil mill	Alcoa	Davenport, Iowa	Westinghouse
131	800	125/530	600	d-c	Geared	Skin pass mill pay-off reel	Great Lakes Steel Corp.	Ecorse, Mich.	Westinghouse
132	800	125/530	600	d-c	Geared	Skin pass mill pay-off reel	Great Lakes Steel Corp.	Ecorse, Mich.	Westinghouse
133	800	125/530	600	d-c	Geared	Skin pass mill pay-off reel	Great Lakes Steel Corp.	Ecorse, Mich.	Westinghouse
134	800	125/530	600	d-c	Geared	Skin pass mill pay-off reel	Great Lakes Steel Corp.	Ecorse, Mich.	Westinghouse
135	800	125/530	600	d-c	Geared	Skin pass mill pay-off reel	Great Lakes Steel Corp.	Ecorse, Mich.	Westinghouse
136*	800	514	‡300	60	Geared	Bar mill	Copperweld Steel Co.	Glassport, Pa.	Westinghouse
137*	800	514	‡300	60	Geared	Bar mill	Copperweld Steel Co.	Glassport, Pa.	Westinghouse
138*	800	720	‡300	60	Geared	Piercing mill	Aetna-Am. Brass Co.	Paramount, Calif.	Westinghouse
139	800	600	‡300	60	Geared	Piercing mill	Babcock & Wilcox Co.	Beaver Falls, Pa.	Westinghouse
140*	800	720	‡300	60	Geared	Merchant and bar mill rougher	Cia Fundidora de Chihuahua	Chihuahua, Mexico	Westinghouse
141	①②800	690/1050	600	d-c	Direct	2-Stand temper mill, stand No. 2	Bethlehem Steel Co.	Sparrows Point, Md.	General Electric
142	①②800	690/1050	600	d-c	Direct	2-Stand temper mill, stand No. 2	Bethlehem Steel Co.	Sparrows Point, Md.	General Electric
143	①②800	690/1050	600	d-c	Direct	2-Stand temper mill, stand No. 2	Bethlehem Steel Co.	Sparrows Point, Md.	General Electric
144	①②800	690/1050	600	d-c	Direct	2-Stand temper mill, stand No. 2	Bethlehem Steel Co.	Sparrows Point, Md.	General Electric
145	800	400/750	600	d-c	Direct	Reversing cold strip mill	U. S. Tube and Foundry Co.	Brooklyn, N. Y.	General Electric
146	800	350/480	600	d-c	Direct	48-in. Skin pass mill	Altos Hornos	Bilboa, Spain	General Electric
147	②800	500/1000	750	d-c	Direct	Temper mill top delivery puller	Weirton Steel Co.	Weirton, W. Va.	General Electric
148	800	‡50/750	700	d-c	Geared	3-Strand rod and merchant mill, stand No. 12, 13	Atlantic Steel Co.	Atlanta, Ga.	General Electric
149	800	‡50/750	700	d-c	Geared	3-Strand rod and merchant mill, stand No. 14, 15	Atlantic Steel Co.	Atlanta, Ga.	General Electric
150	800	‡25/675	600	d-c	Geared	Rod mill, stand No. 2 and 3	Keystone Steel and Wire Co.	Peoria, Ill.	Elliott
151	800	‡25/675	600	d-c	Geared	Rod mill, stand No. 4 and 5	Keystone Steel and Wire Co.	Peoria, Ill.	Elliott
152	800	‡25/675	600	d-c	Geared	Rod mill, stand No. 6 and 7	Keystone Steel and Wire Co.	Peoria, Ill.	Elliott
153	800	‡25/675	600	d-c	Geared	Rod mill, stand No. 8 and 9	Keystone Steel and Wire Co.	Peoria, Ill.	Elliott
154	1000	500/1000	600	d-c	Direct	Aluminum foil mill	Alcoa	Alcoa, Tenn.	General Electric
155	1000	500/1000	600	d-c	Direct	Aluminum foil mill	Alcoa	Alcoa, Tenn.	General Electric
156	1000	500/1000	600	d-c	Direct	Aluminum foil mill	Alcoa	Alcoa, Tenn.	General Electric
157	1000	500/1000	600	d-c	Direct	Aluminum foil mill	Alcoa	Alcoa, Tenn.	General Electric
158	1000	500/1000	600	d-c	Direct	Aluminum foil mill	Alcoa	Alcoa, Tenn.	General Electric
159	1000	500/1000	600	d-c	Direct	Aluminum foil mill	Alcoa	Alcoa, Tenn.	General Electric
160	1000	300/900	600	d-c	Geared	12-in. Bar mill	Rotary Electric Steel Co.	Detroit, Mich.	General Electric
161	1000	‡00/750	600	d-c	Geared	18-in. Bar mill	Rotary Electric Steel Co.	Detroit, Mich.	General Electric
162	②1000	‡50/1300	750	d-c	Direct	2-Stand temper mill reel	Youngstown Sheet and Tube Co.	Indiana Harbor, Ind.	General Electric
163	②1000	‡50/1250	750	d-c	Direct	2-Stand temper mill reel	Weirton Steel Co.	Weirton, W. Va.	General Electric
164	②1000	‡50/1250	750	d-c	Direct	2-Stand temper mill reel	Weirton Steel Co.	Weirton, W. Va.	General Electric
165	②1000	‡50/850	600	d-c	Geared	Single stand temper mill reel	Armco Steel Corp.	Middletown, Ohio	General Electric
166	1000	‡25/450	600	d-c	Geared	49-in. Sendzimir mill reel	Washington Steel Corp.	Washington, Pa.	General Electric
167	1000	‡25/450	600	d-c	Geared	49-in. Sendzimir mill reel	Washington Steel Corp.	Washington, Pa.	General Electric
168	1000	‡25/281	600	d-c	Direct	49-in. Sendzimir mill	Washington Steel Corp.	Washington, Pa.	General Electric
169	②1000	100/430	600	d-c	Geared	3-Stand tandem cold mill reel	Republic Steel Corp.	Gadsden, Ala.	General Electric
170	1000	150/515	600	d-c	Direct	4-Stand tandem cold mill	Chase Brass and Copper Co.	Cleveland, Ohio	Westinghouse
171	1000	‡00/600	600	d-c	Direct	4-Stand tandem cold mill	Chase Brass and Copper Co.	Cleveland, Ohio	Westinghouse
172	②1000	400/1110	600	d-c	Direct	4-Stand tandem cold mill	Chase Brass and Copper Co.	Cleveland, Ohio	Westinghouse
173	②1000	500/1220	600	d-c	Direct	4-Stand tandem cold mill	Chase Brass and Copper Co.	Cleveland, Ohio	Westinghouse
174	1000	‡25/450	600	d-c	Direct	Foil mill	Alcoa	Davenport, Iowa	Westinghouse
175	1000	450/900	600	d-c	Direct	Foil mill	Alcoa	Davenport, Iowa	Westinghouse
176	1000	450/900	600	d-c	Direct	Foil mill	Alcoa	Davenport, Iowa	Westinghouse
177	1000	350/875	600	d-c	Direct	4-High aluminum finishing mill	Sheet Aluminum Division of Mueller Brass Co.	Jackson, Mich.	Westinghouse
178	1000	575/1185	600	d-c	Direct	Aluminum foil mill	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	Westinghouse
179	1000	575/1185	600	d-c	Direct	Aluminum foil mill	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	Westinghouse

*Indicates synchronous motor. †Induction motor. ①Twin motor drive. ②Double armature. ③Triple armature. ④One-half double armature.

ELECTRIC MOTOR DRIVES THREE HUNDRED HORSEPOWER AND OVER
(CONTINUED)

Item	Horsepower	Revolutions per minute	Volts	Frequency	Method of drive	Type of mill	Purchaser	Location	Manufacturer
180	1000	400/800	600	d-c	Geared	Merchant mill	Northeastern Steel Corp.	Bridgeport, Conn.	Westinghouse
181	1000	175/612.5	500	d-c	Geared	Merchant bar mill intermediate stand	Cia Fundidora de Chihuahua	Chihuahua, Mexico	Westinghouse
182	1000	275/550	600	d-c	Direct	54-in. Single stand temper mill	Republic Steel Corp.	Gadsden, Ala.	Allis Chalmers
183	1000	850/1220	750	d-c	Direct	2-Stand temper mill puller	Youngstown Sheet and Tube Co.	Indiana Harbor, Ind.	General Electric
184	1000	850/1220	750	d-c	Direct	2-Stand temper mill puller	Youngstown Sheet and Tube Co.	Indiana Harbor, Ind.	General Electric
185	②1000	300/900	750	d-c	Geared	Aluminum hot strip mill coiler	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	General Electric
186	②1000	300/900	750	d-c	Geared	Aluminum hot strip mill coiler	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	General Electric
187	②1200	300/1050	600	d-c	Geared	Temper mill reel	Jones & Laughlin Steel Corp.	Cleveland, Ohio	General Electric
188	②1200	300/1050	600	d-c	Geared	54-in. Single stand temper mill	Republic Steel Corp.	Gadsden, Ala.	Allis Chalmers
189	②1200	150/560	600	d-c	Geared	Reversing cold mill reel	Armco Steel Corp.	Ashland, Ky.	General Electric
190	②1200	150/560	600	d-c	Geared	Reversing cold mill reel	Armco Steel Corp.	Ashland, Ky.	General Electric
191	1250	350/500	750	d-c	Direct	2-Stand temper mill	Youngstown Sheet and Tube Co.	Indiana Harbor, Ind.	General Electric
192	④1250	100/300	600	d-c	Direct	4-Stand cold mill, stand No. 1	Allegheny Ludlum Steel Corp.	Brackenridge, Pa.	General Electric
193	1250	450/900	600	d-c	Direct	Foil mill	Alcoa	Davenport, Iowa	Westinghouse
194	1250	125/250	600	d-c	Geared	Aluminum slab mill	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	Westinghouse
195	1250	60/180	600	d-c	Direct	Merchant mill	Northeastern Steel Corp.	Bridgeport, Conn.	Westinghouse
196	1250	200/400	600	d-c	Direct	Sendzimir mill	Eastern Stainless Steel Corp.	Baltimore, Md.	Westinghouse
197	1250	200/600	600	d-c	Geared	Sendzimir mill	Eastern Stainless Steel Corp.	Baltimore, Md.	Westinghouse
198	1250	200/600	600	d-c	Geared	Sendzimir mill	Eastern Stainless Steel Corp.	Baltimore, Md.	Westinghouse
199	1250	250/530	600	d-c	Direct	32-in. Temper mill	Alan Wood Steel Co.	Conshohocken, Pa.	Westinghouse
200	1250	600/800	600	d-c	Geared	Tandem cold mill	Bethlehem Steel Co.	Sparrows Point, Md.	Elliott
201	②1400	185/650	750	d-c	Direct	4-Stand tandem cold mill reel	Jones & Laughlin Steel Corp.	Cleveland, Ohio	General Electric
202	②1500	450/900	750	d-c	Direct	2-Stand temper mill, stand No. 2	Weirton Steel Co.	Weirton, W. Va.	General Electric
203	1500	350/500	750	d-c	Direct	2-Stand tamper mill, stand No. 2	Youngstown Sheet and Tube Co.	Indiana Harbor, Ind.	General Electric
204	⑤1500	300/1400	600	d-c	Direct	5-Stand tandem cold mill reel	Bethlehem Steel Co.	Sparrows Point, Md.	General Electric
205	1500	250/500	600	d-c	Direct	34-in Reversing cold mill	Altos Hornos	Bilboa, Spain	General Electric
206	③1500	175/700	600	d-c	Direct	Skin pass mill	Weirton Steel Co.	Weirton, W. Va.	Westinghouse
207	③1500	300/1120	600	d-c	Direct	Cold mill	Wheeling Steel Corp.	Yorkville, Ohio	Westinghouse
208	*1500	600	2300	60	Geared	18-in. roughing mill	U. S. Steel Corp.	Joliet, Ill.	General Electric
209	*1500	600	2300	60	Geared	12-in. Intermediate mill, No. 1 drive	U. S. Steel Corp.	Joliet, Ill.	General Electric
210	1500	90/225	700	d-c	Geared	Strip mill edger	Jones & Laughlin Steel Corp.	Cleveland, Ohio	Westinghouse
211	1500	300/600	250	d-c	Direct	Assel mill	Babcock and Wilcox Co.	Beaver Falls, Pa.	Westinghouse
212	1500	225/560	600	d-c	Geared	44-in. 4-Stand tandem cold mill	Alcoa	Alcoa, Tenn.	Allis Chalmers
213	1500	225/560	600	d-c	Geared	44-in. 4-Stand tandem cold mill	Alcoa	Alcoa, Tenn.	Allis-Chalmers
214	1500	225/560	600	d-c	Geared	44-in. 4-Stand tandem cold mill	Alcoa	Alcoa, Tenn.	Allis Chalmers
215	1500	225/560	600	d-c	Direct	44-in. 4-Stand tandem cold mill	Alcoa	Alcoa, Tenn.	Allis Chalmers
216	1750	400/800	600	d-c	Geared	48-in. Reversing cold mill	Altos Hornos	Bilboa, Spain	General Electric
217	④1750	200/500	600	d-c	Direct	4-Stand cold mill, stand No. 4	Allegheny Ludlum Steel Corp.	Brackenridge, Pa.	General Electric
218	1750	80/240	600	d-c	Direct	5-Stand tandem cold mill	Bethlehem Steel Co.	Sparrows Point, Md.	General Electric
219	①1750	150/375	750	d-c	Geared	4-Stand tandem cold mill, stand No. 1	Jones & Laughlin Steel Corp.	Cleveland, Ohio	General Electric
220	①1750	150/375	750	d-c	Geared	4-Stand tandem cold mill, stand No. 1	Jones & Laughlin Steel Corp.	Cleveland, Ohio	General Electric
221	2000	500/900	700	d-c	Geared	3-Strand rod and merchant mill, stands No. 16 through 21	Atlantic Steel Co.	Atlanta, Ga.	General Electric
222	②2000	350/700	750	d-c	Direct	2-Stand temper mill, stand No. 1	Weirton Steel Co.	Weirton, W. Va.	General Electric
223	④2000	200/580	750	d-c	Direct	Tandem cold mill, stand No. 3	Breedband N.V.	Holland	General Electric
224	④2000	175/450	600	d-c	Direct	4-Stand cold mill, stand No. 3	Allegheny Ludlum Steel Corp.	Brackenridge, Pa.	General Electric
225	④2000	135/380	600	d-c	Direct	4-Stand cold mill, stand No. 2	Allegheny Ludlum Steel Corp.	Brackenridge, Pa.	General Electric
226	①2000	150/325	600	d-c	Direct	5-Stand tandem cold mill, stand No. 3	Bethlehem Steel Co.	Sparrows Point, Md.	General Electric
227	①2000	150/325	600	d-c	Direct	5-Stand tandem cold mill, stand No. 3	Bethlehem Steel Co.	Sparrows Point, Md.	General Electric
228	2000	125/160	750	d-c	Direct	Plug mill	Mannesmann Tube Co.	Sault Ste. Marie, Canada	General Electric
229	2000	125/160	750	d-c	Direct	Plug mill	Mannesmann Tube Co.	Sault Ste. Marie, Canada	General Electric
230	2000	80/240	750	d-c	Direct	Cold mill	Wheeling Steel Corp.	Yorkville, Ohio	Westinghouse
231	①2000	150/325	750	d-c	Geared	Cold mill	Wheeling Steel Corp.	Yorkville, Ohio	Westinghouse
232	①2000	150/325	750	d-c	Geared	Cold mill	Wheeling Steel Corp.	Yorkville, Ohio	Westinghouse
233	†2000	500	3300	50	Geared	Hot sheet mill	Manufacturos Metallicas Madrilenas	Madrid, Spain	Westinghouse
234	②2000	300/900	600	d-c	Direct	Aluminum sheet mill	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	Westinghouse
235	2000	200/400	600	d-c	Geared	Aluminum slab mill	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	Westinghouse
236	2000	75	11500	60	Direct	Seamless tube mill	Youngstown Sheet and Tube Co.	Indiana Harbor, Ind.	Westinghouse
237	2000	800	600	d-c	Geared	Merchant mill	Northeastern Steel Corp.	Bridgeport, Conn.	Westinghouse
238	†2000	590	2300	60	Geared	Piercing mill	Babcock and Wilcox Co.	Beaver Falls, Pa.	Westinghouse
239	†2000	590	2300	60	Geared	Piercing mill	Babcock and Wilcox Co.	Beaver Falls, Pa.	Westinghouse
240	*2000	150	600	50	Geared	Scale breaker	Empressa Nacional Siderurgica	Madrid, Spain	Westinghouse
241	①2500	225/500	600	d-c	Direct	5-Stand tandem cold mill, stand No. 4	Bethlehem Steel Co.	Sparrows Point, Md.	General Electric
242	①2500	225/500	600	d-c	Direct	5-Stand tandem cold mill, stand No. 4	Bethlehem Steel Co.	Sparrows Point, Md.	General Electric
243	2500	175/375	600	d-c	Direct	42-in. Tandem cold mill, stand No. 3	Republic Steel Corp.	Warren, Ohio	General Electric
244	2500	135/305	600	d-c	Direct	42-in. Tandem cold mill, stand No. 2	Republic Steel Corp.	Warren, Ohio	General Electric
245	2500	90/225	600	d-c	Direct	42-in. Tandem cold mill, stand No. 1	Republic Steel Corp.	Warren, Ohio	Westinghouse
246	①2500	225/500	750	d-c	Geared	Cold mill	Wheeling Steel Corp.	Yorkville, Ohio	Westinghouse
247	①2500	225/500	750	d-c	Geared	Cold mill	Wheeling Steel Corp.	Yorkville, Ohio	Westinghouse
248	2500	400/690	600	d-c	Geared	Rod mill, stands No. 18 to 23	Keystone Steel and Wire Co.	Peoria, Ill.	Elliott
249	①②2700	275/550	600	d-c	Direct	5-Stand tandem cold mill, stand No. 5	Bethlehem Steel Co.	Sparrows Point, Md.	General Electric
250	①②2700	275/550	600	d-c	Direct	5-Stand tandem cold mill, stand No. 5	Bethlehem Steel Co.	Sparrows Point, Md.	General Electric
251	3000	225/430	750	d-c	Geared	6-Stand hot strip finishing mill, stand No. 2	Jones & Laughlin Steel Corp.	Aliquippa, Pa.	General Electric
252	3000	225/430	750	d-c	Geared	6-Stand hot strip finishing mill, stand No. 1	Jones & Laughlin Steel Corp.	Aliquippa, Pa.	General Electric
253	①3000	225/485	750	d-c	Geared	4-Stand tandem cold mill, stand No. 2	Jones & Laughlin Steel Corp.	Cleveland, Ohio	General Electric
254	①3000	225/485	750	d-c	Geared	4-Stand tandem cold mill, stand No. 2	Jones & Laughlin Steel Corp.	Cleveland, Ohio	General Electric
255	①3000	225/485	750	d-c	Geared	4-Stand tandem cold mill, stand No. 3	Jones & Laughlin Steel Corp.	Cleveland, Ohio	General Electric
256	①3000	225/485	750	d-c	Geared	4-Stand tandem cold mill, stand No. 3	Jones & Laughlin Steel Corp.	Cleveland, Ohio	General Electric
257	①3000	225/485	750	d-c	Geared	4-Stand tandem cold mill, stand No. 4	Jones & Laughlin Steel Corp.	Cleveland, Ohio	General Electric
258	①3000	225/485	750	d-c	Geared	4-Stand tandem cold mill, stand No. 4	Jones & Laughlin Steel Corp.	Cleveland, Ohio	General Electric
259	3000	200/400	750	d-c	Direct	6-Stand hot strip finishing mill, stand No. 6	Jones & Laughlin Steel Corp.	Aliquippa, Pa.	General Electric
260	3000	150/300	750	d-c	Direct	6-Stand hot strip finishing mill, stand No. 5	Jones & Laughlin Steel Corp.	Aliquippa, Pa.	General Electric
261	3000	125/250	750	d-c	Direct	6-Stand hot strip finishing mill, stand No. 4	Jones & Laughlin Steel Corp.	Aliquippa, Pa.	General Electric
262	3000	90/180	750	d-c	Direct	6-Stand hot strip finishing mill, stand No. 3	Jones & Laughlin Steel Corp.	Aliquippa, Pa.	General Electric
263	①3000	275/550	750	d-c	Geared	Cold mill	Wheeling Steel Corp.	Yorkville, Ohio	Westinghouse
264	①3000	275/550	750	d-c	Geared	Cold mill	Wheeling Steel Corp.	Yorkville, Ohio	Westinghouse
265	①3000	40/100	700	d-c	Direct	Rougher	Jones & Laughlin Steel Corp.	Aliquippa, Pa.	Westinghouse
266	①3000	40/100	700	d-c	Direct	Rougher	Jones & Laughlin Steel Corp.	Aliquippa, Pa.	Westinghouse
267	3000	225/450	600	d-c	Geared	100-in. Cold mill	Alcoa	Davenport, Iowa	Westinghouse
268	3500	150/336	700	d-c	Geared	Hot strip mill	Republic Steel Corp.	Gadsden, Ala.	Westinghouse
269	3500	150/300	700	d-c	Geared	Hot strip mill	Republic Steel Corp.	Gadsden, Ala.	Westinghouse
270	3500	110/220	700	d-c	Direct	Hot strip mill	Republic Steel Corp.	Gadsden, Ala.	Westinghouse
271	3500	135/270	700	d-c	Direct	Hot strip mill	Republic Steel Corp.	Gadsden, Ala.	Westinghouse
272	③3500	175/550	600	d-c	Geared	Aluminum cold mill	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	Westinghouse

*Indicates synchronous motor. †Induction motor. ①Twin motor drive. ②Double armature. ③Triple armature. ④One-half double armature.

Item	Horsepower	Revolutions per minute	Volts	Frequency	Method of drive	Type of mill	Purchaser	Location	Manufacturer
273	3500	50/150	700	d-c	Direct	Roughing mill	Crucible Steel Co.	Midland, Pa.	Westinghouse
274	①3500	30/60	600	d-c	Direct	160-in. Slabbing mill	Alcoa	Davenport, Iowa	Westinghouse
275	①3500	30/60	600	d-c	Direct	160-in. Slabbing mill	Alcoa	Davenport, Iowa	Westinghouse
276	①3500	40/80	700	d-c	Direct	Plate mill	Empressa Nacional Siderurgica	Madrid, Spain	Westinghouse
277	①3500	40/80	700	d-c	Direct	Plate mill	Empressa Nacional Siderurgica	Madrid, Spain	Westinghouse
278	3500	175/550	750	d-c	Direct	Aluminum cold strip mill, stand No. 2	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	General Electric
279	3500	110/415	750	d-c	Direct	Aluminum cold strip mill, stand No. 1	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	General Electric
280	3500	175/375	600	d-c	Direct	3-Stand tandem cold mill, stand No. 3	Republic Steel Corp.	Gadsden, Ala.	General Electric
281	3500	175/350	750	d-c	Direct	Hot strip mill, add No. 5 stand	Detroit Steel Corp.	Portsmouth, Ohio	General Electric
282	②3500	150/360	600	d-c	Direct	5-Stand tandem cold mill, stand No. 2	Bethlehem Steel Co.	Sparrows Point, Md.	General Electric
283	3500	150/352	600	d-c	Geared	Hot strip finishing mill, stand No. 1	Breedband N.V.	Holland	General Electric
284	3500	90/1225	600	d-c	Geared	3-Stand tandem cold mill, stand No. 1	Republic Steel Corp.	Gadsden, Ala.	General Electric
285	3500	155/305	600	d-c	Direct	3-Stand tandem cold mill, stand No. 2	Republic Steel Corp.	Gadsden, Ala.	General Electric
286	*4000	600	4000	60	Geared	Piercing mill	Mannesmann Tube Co.	Sault Ste. Marie, Canada	General Electric
287	*4000	600	4000	60	Geared	Piercing mill	Mannesmann Tube Co.	Sault Ste. Marie, Canada	General Electric
288	①4000	40/100	900	d-c	Direct	Blooming mill	Sharon Steel Corp.	Sharon, Pa.	General Electric
289	①4000	40/100	900	d-c	Direct	Blooming mill	Sharon Steel Corp.	Sharon, Pa.	General Electric
290	②4000	250/850	750	d-c	Direct	Tandem cold mill, stand No. 4	Breedband N.V.	Holland	General Electric
291	4000	175/350	750	d-c	Direct	Reversing cold mill	Armco Steel Corp.	Ashland, Ky.	General Electric
292	4000	150/410	750	d-c	Geared	5-Stand aluminum hot strip mill, stand No. 5	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	General Electric
293	4000	125/250	700	d-c	Direct	Hot strip mill	Armco Steel Corp.	Butler, Pa.	Westinghouse
294	4000	140/310	700	d-c	Direct	Hot strip mill	Armco Steel Corp.	Butler, Pa.	Westinghouse
295	4000	60/150	700	d-c	Geared	Strip mill	Republic Steel Corp.	Gadsden, Ala.	Westinghouse
296	4000	150/360	750	d-c	Direct	Cold mill	Wheeling Steel Corp.	Yorkville, Ohio	Westinghouse
297	①4000	40/80	600	d-c	Direct	Strip mill rougher	Jones & Laughlin Steel Corp.	Cleveland, Ohio	Westinghouse
298	①4000	40/80	600	d-c	Direct	Strip mill rougher	Jones & Laughlin Steel Corp.	Cleveland, Ohio	Westinghouse
299	*4000	257	11500	60	Geared	Seamless tube mill	Youngstown Sheet and Tube Co.	Indiana Harbor, Ind.	Westinghouse
300	*4000	257	11500	60	Geared	Seamless tube mill	Youngstown Sheet and Tube Co.	Indiana Harbor, Ind.	Westinghouse
301	4000	175/350	700	d-c	Direct	Finishing mill	Voest	Linz, Austria	Westinghouse
302	5000	125/250	700	d-c	Geared	Hot strip mill	Armco Steel Corp	Butler, Pa.	Westinghouse
303	5000	125/250	700	d-c	Geared	Hot strip mill	Armco Steel Corp.	Butler, Pa.	Westinghouse
304	5000	95/190	700	d-c	Direct	Hot strip mill	Armco Steel Corp.	Butler, Pa.	Westinghouse
305	①5000	40/100	700	d-c	Direct	Slabbing mill	Jones & Laughlin Steel Corp.	Cleveland, Ohio	Westinghouse
306	②5000	40/100	700	d-c	Direct	Slabbing mill	Jones & Laughlin Steel Corp.	Cleveland, Ohio	Westinghouse
307	①②5000	50/60	600	d-c	Direct	Aluminum slab mill	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	Westinghouse
308	①②5000	30/60	600	d-c	Direct	Aluminum slab mill	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	Westinghouse
309	5000	150/370	750	d-c	Geared	5-Stand aluminum hot strip mill, stand No. 1	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	General Electric
310	5000	150/370	750	d-c	Geared	5-Stand aluminum hot strip mill, stand No. 2	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	General Electric
311	5000	150/370	750	d-c	Geared	5-Stand aluminum hot strip mill, stand No. 3	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	General Electric
312	5000	150/370	750	d-c	Geared	5-Stand aluminum hot strip mill, stand No. 4	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	General Electric
313	5000	125/250	750	d-c	Geared	60-in. Hot strip finishing mill, stand No. 1	McLouth Steel Corp.	Trenton, Mich.	General Electric
314	①5000	40/80	750	d-c	Direct	Plate mill	Bethlehem Steel Co.	Sparrows Point, Md.	General Electric
315	①5000	40/80	750	d-c	Direct	Plate mill	Bethlehem Steel Co.	Sparrows Point, Md.	General Electric
316	5000	50/100	700	d-c	Direct	35-in. Blooming mill	Copperweld Steel Co.	Warren, Ohio	Allis Chalmers
317	①6000	40/80	700	d-c	Direct	Slabbing mill	Republic Steel Corp.	Cleveland, Ohio	Westinghouse
318	①6000	40/80	700	d-c	Direct	Slabbing mill	Republic Steel Corp.	Cleveland, Ohio	Westinghouse
319	6000	30/60	600	d-c	Direct	Aluminum slab mill	Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	Westinghouse
320	7000	40/100	700	d-c	Direct	Rougher	Armco Steel Corp.	Butler, Pa.	Westinghouse

*Indicates synchronous motor. †Induction motor. ①Twin motor drive. ②Double armature. ③Triple armature. ④One-half double armature.

MOTOR RECAPITULATION

Company	Location	Type of mill	Number of motors	Total horsepower
Aetna American Brass Co.	Paramount, Calif.	Piercing mill	1	800
Alan Wood Steel Co.	Conshohocken, Pa.	32-in. Temper mill	2	1,600
Alcoa	Alcoa, Tenn.	Aluminum foil mills	6	6,000
		44-in. 4-Stand tandem cold mill	5	6,500
	Davenport, Iowa	Foil mills	9	7,750
		100-in. Cold mill	1	5,000
		Slabbing mill	2	7,000
Allegheny Ludlum Steel Corp.	Brackenridge, Pa.	4-Stand cold mill	4	7,000
Altos Hornos de Vizcaya	Bilboa, Spain	48-in. Reversing cold mill	5	4,250
		34-in. Reversing cold mill	3	2,700
Armco Steel Corp.	Butler, Pa.	Wheel mill edger	2	800
		Hot strip mill	7	30,600
	Ashland, Ky.	Reversing cold mill	5	6,400
	Middletown, Ohio	Single stand temper mill	2	1,750
Atlantic Steel Co.	Atlanta, Ga.	Rod and merchant mill	13	8,300
Babcock and Wilcox Co.	Beaver Falls, Pa.	Tube mill	7	7,300
Bethlehem Steel Co.	Sparrows Point, Md.	Pickle line processors	2	750
		Skin pass mill	3	1,200
		2-Stand temper mill	6	3,800
		2-Stand temper mill	6	3,800
		5-Stand tandem cold mill	10	22,400
		Plate mill	2	10,000
Breedband, N.V.	Holland	Tandem cold mill	5	6,600
		Hot strip finishing	1	3,500
Bridgeport Brass Co.	Bridgeport, Conn.	Sendzimir mill	1	500
Chase Brass and Copper Co.	Cleveland, Ohio	Tandem cold mill	5	4,400
Cia Fundidora de Chihuahua	Chihuahua, Mexico	Merchant and bar mill	4	3,000
Cochran Foil Products Co.	Louisville, Ky.	60-in. Foil mill	3	1,150
Cold Metal Products of California	Los Angles, Calif.	Reversing cold mill	1	300
Copperweld Steel Co.	Warren, Ohio	Blooming mill	1	5,000
	Glassport, Pa.	Bar mill	2	1,600
Crucible Steel Co.	Midland, Pa.	Rod and merchant mill	6	3,600
		Roughing mill	1	3,500
Detroit Steel Corp.	Portsmouth, Ohio	Hot strip mill	1	3,500
Eastern Stainless Steel Corp.	Baltimore, Md.	Sendzimir mill	3	3,750
Empresa Nacional Siderurgica	Aviles, Astunas, Spain	Plate mill	4	9,600
Great Lakes Steel Corp.	Ecorse, Mich.	Skin pass mill	5	4,000
Inland Steel Co.	Indiana Harbor, Ind.	Shear drive	3	1,500
Jones & Laughlin Steel Corp.	Aliquippa, Pa.	Hot strip mill	11	25,750
	Cleveland, Ohio	Temper mill	3	2,200

MOTOR RECAPITULATION
(CONTINUED)

Company	Location	Type of mill	Number of motors	Total horsepower
		4-Stand tandem cold strip mill	9	22,900
		Hot strip mill rougher	3	9,500
		Slabbing mill	2	10,000
Johnson Tin Foil and Metals Co.	St. Louis, Mo.	60-in. Foil mill	1	450
Kaiser Aluminum and Chemical Corp.	Ravenswood, W. Va.	Aluminum sheet mill	3	2,800
		Aluminum cold mill	4	4,500
		Slab shear	2	1,000
		Aluminum foil mill	2	2,000
		5-Stand aluminum hot strip mill	7	26,000
		Aluminum slab mill	5	19,250
		2-Stand aluminum cold strip mill	6	8,400
Keystone Steel and Wire Co.	Peoria, Ill.	Rod mill	14	10,000
Mannesmann Tube Co.	Sault Ste. Marie, Canada	Tube mill	9	14,200
Manufacturus Metallicas Madrilenas	Madrid, Spain	Hot sheet mill	1	2,000
Mueller Brass Co., Sheet Aluminum Division	Jackson, Mich.	4-High aluminum finishing mill	2	1,300
McLouth Steel Corp.	Trenton, Mich.	60-in. Hot strip finishing mill, stand No. 1	1	5,000
National Lead Co.	Granite City, Ill	Reversing hot mill	1	300
Northeastern Steel Corp.	Bridgeport, Conn.	Merchant mill	6	5,350
Republic Steel Corp.	Buffalo, N. Y.	Bar mill	2	1,400
	Cleveland, Ohio	Slabbing mill	2	12,000
	Gadsden, Ala.	54-in. Single stand temper mill	2	2,200
		3-Stand tandem cold mill	4	11,500
	Warren, Ohio	Hot strip mill	5	18,000
Rotary Electric Steel Co.	Detroit, Mich.	42-in. Tandem cold mill	4	8,250
		10-in Bar mill	1	600
		12-in Bar mill	1	1,000
		18-in. Bar mill	1	1,000
Sharon Steel Corp.	Sharon, Pa.	Blooming mill	2	8,000
Simonds Saw and Steel Co.	Lockport, N. Y.	4-High non-reversing mill	1	400
Somers Brass Co.	Waterbury, Conn.	Sendzimir reversing cold mill	3	1,200
U. S. Steel Corp.	Pittsburgh, Pa.	Reversing hot mill	2	875
	Joliet, Ill.	Rod mill	3	3,500
U. S. Tube and Foundry Co.	Brooklyn, N. Y.	Reversing cold strip mill	1	800
Voest	Linz, Austria	Finishing mill stand	1	4,000
Washington Steel Corp.	Washington, Pa.	49-in. Sendzimir mill	3	3,000
Wheeling Steel Corp.	Yorkville, Ohio	51-in. Cold mill	9	22,500
		51-in., 2-Stand temper mill	8	4,584
Weirton Steel Co.	Weirton, W. Va.	Temper mill pullers	4	2,000
		Skin pass mill	4	3,750
		2-Stand temper mill	4	5,500
Youngstown Sheet and Tube Co.	Indiana Harbor, Ind.	2-Stand temper mill	7	6,450
		Seamless tube	9	12,700

Type of motors purchased	Number of motors	Total horsepower
Alternating-current motors	30	37,400
Direct-current motors	290	469,909
Total	320	507,309

a thin film polyester type, which has high heat resistance properties as well as excellent resistance to abrasion and solvents. This insulation is able to withstand hot spot temperatures up to 150 C, and is designed for the class B high temperature range. Magnet wire thus insulated is now available in sizes from No. 13 through No. 26, with single and heavy wall film thicknesses.

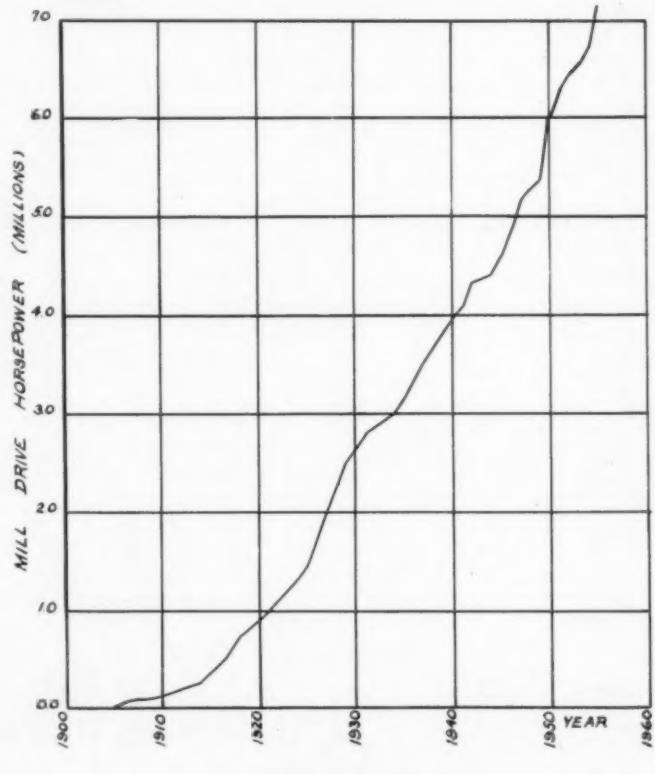
Another manufacturer is adopting the use of an all-silicone rubber insulation system in its large motors and generators. This material is a pure silicone rubber gum compounded with silica, and has a thermal conductivity about twice that of organic rubber or resinous insulating components. Thus, coils will operate under the same load at temperatures as much as 50 per cent below the temperature of identical coils of the usual type.

An improved incandescent light bulb now on the market has increased light output by 6 to 15 per cent with no additional power requirements. This improvement was accomplished through improving the tungsten filament, by altering the mounting structure so that the filament is positioned lengthwise or axially in the bulb, and by substituting, coiled-coil filaments for singly coiled ones in lamps of 300 watts and larger.

Industrial television is being used more and more in the steel plant, particularly where manpower requirements can be reduced or hazardous conditions are present. Applications using television include observation of pouring operations or furnace interiors, position of slabs out of reheating furnaces, etc.

Sales of main drives during the year were the second largest in history and not far from a new record. The horsepower of main roll drives sold in 1955 totaled 507,309 from 320 motors, of which 290 were d-c and 30 were a-c.

Accumulative curve of main drive motors over 300 hp shows a total as of January 1, 1956 of 7,204,154 hp. Three hundred and twenty motors (507,309 hp), were added in 1955 of which 290 were d-c and 30 were a-c. This is about three times more than the total added in 1954.



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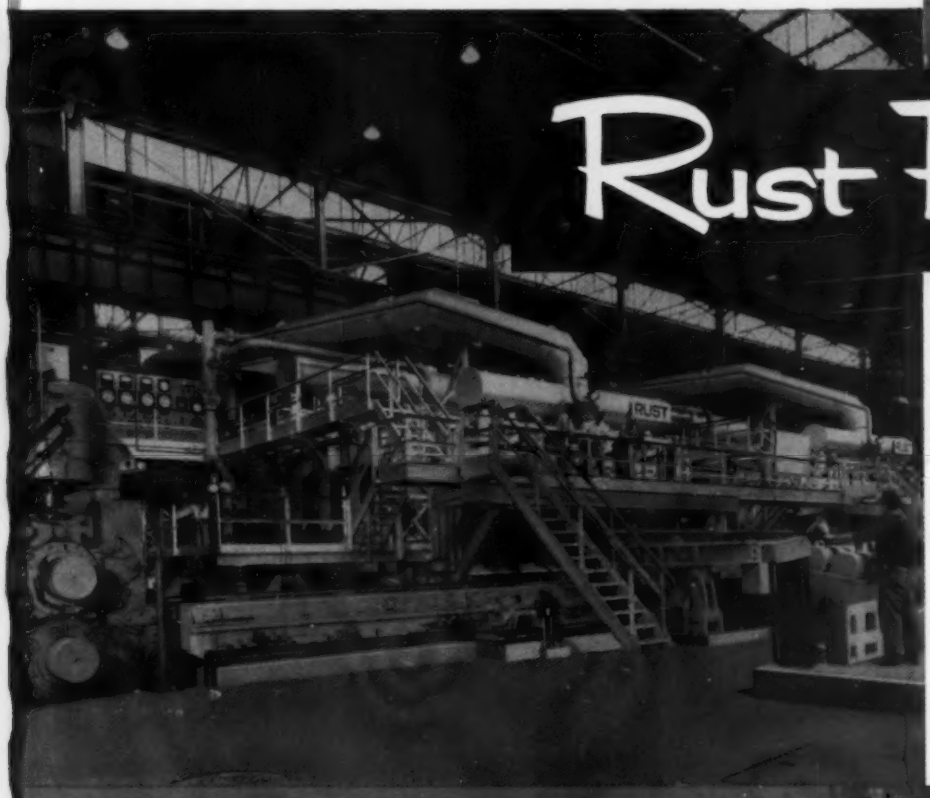

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- BOX ANNEALING FURNACES
- CONTINUOUS PIPE ANNEALING
- CONTINUOUS STRIP ANNEALING
- GALVANIZING, WIRE PATENTING
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1955 - A Record Year for the heat treating industry

By
CARL L. IPSEN,
Executive Vice President
Industrial Heating Equipment Association
Washington, D. C.

automatic carbon potential control, toward austempering and martempering to reduce distortion of heated parts. Vacuum melting and vacuum heat treating are "growing up." There is more "upgrading" of cheap steels to do the job of expensive alloys, and an ever-increasing use of controlled or protective atmospheres

▲ 1955 was a year of technical advance, interesting installations, and record-breaking peacetime business so far as the industrial heating equipment industry is concerned.

For the most part, executives in the industry credit this record to technical engineering advances. For most operations, the advantages of modern equipment in cutting costs, upgrading materials, and effecting savings in the use of human labor, are so obvious that replacement of obsolete equipment has provided more than its usual quota of sales.

Volume of business for 1955 in our industry was 195 per cent of the volume of 1954, which was, itself, a good peacetime year. A survey attempting to forecast business for 1956 among the member companies of the Industrial Heating Equipment Association indicates a drop in business. Executives predicted that 1956 business would fall off about 12 per cent from this year's totals. That would still be 171 per cent of 1954 business.

Numerous trends were reported in the heat treating of iron and steel and its products. Among them are the increased use of mechanization or automation, an increased swing toward to prevent scaling and discoloration and thus avoid the high cost of subsequent cleaning operations.

It is of interest to the Association of Iron and Steel Engineers to state that the engineering shortage, which has bothered so many industries, is also causing concern in ours. This is because a tremendously increased amount of engineering is going into each installation. Several member companies have commented that they have difficulty getting as many qualified engineers as they need. Not too many years ago, an industrial furnace was often jokingly referred to as a "tin can filled with bricks." Now, however, so many refinements, mechanisms and automatic devices have been added that the modern industrial furnace requires a very large number of engineering manhours.

The following are some capsule-sized items of outstanding trends, highlights and installations which a year-end survey of the industrial heating industry discloses:

1. Mechanization or "automation," is definitely on the increase. Mechanization in several installations made during 1955 must have reached pretty much the ultimate state. Heat treat furnaces were linked with other production equipment, thus eliminating all manual handling operations from the previous machining operation to the final delivery of the heat treated and tempered part.

One member company reports the installation of a roller hearth furnace and pressure quench for heat treating plate steel at a Pennsylvania steel plant. It is the largest on record, rated for 25 tons per hour capacity of plate up to 3 in. thick, up to fourteen ft wide and forty-five ft long. The entire line is under the control of one man, installed in an operating room above the equipment. Television cameras enable him to see six different points that he could not otherwise see.

A similar furnace is now going into another steel plant, the company making the installation reports.

2. Carbon potential control for carburizing, carbonitriding, homogeneous carburizing, carbon restoration, and for heat treating high carbon steels seems to have come of age. Carbon content can now be automatically controlled to within a point or point and a half with new equipment now available.

3. Martempering and austempering to check distortion of parts is becoming increasingly important since the recent development of high velocity, molten salt and hot oil quenching baths.

4. The heat treatment of structural shapes is in the offing. One company reports that it expects the first commercial installation to be in operation next year. By this simple process the strength of structural shapes is almost doubled.

5. Homogeneous carburization, the application of controlled atmospheres to raising the carbon level throughout the section of low carbon steel parts, is increasingly popular. This process permits the user to combine the forming and fabrication advantages of low carbon steel with the mechanical properties of a higher carbon steel, at no materially increased cost. The homogeneous carburizing process can be followed by a hardening treatment.

6. Increased use of pearlitic malleable iron is calling for higher standards of heat treatment and better furnace equipment.

7. The single stack portable base furnace is gaining in popularity in the steel industry. Many large installations of single stack furnaces were reported in steel plants in 1955. A modification of the high convection system used for heating and cooling steel strip coils, combined with additional fuel inputs, shows an increased yield for this furnace of about approximately 50 per cent,

thus reducing floor space requirements and inventory tie-up.

8. Uniformity of case hardening by means of recirculating fan applications in batch type furnaces has been subjected to great refinements and improvements in the last year.

9. One company reports a particularly interesting installation in 1955. It notes a "trend" toward the use of continuous lines for the annealing of tin plate and the galvanizing of strip. The company reports it is installing a 60 ton per hour, 2000 fpm tin plate annealing line which has twice the speed and capacity of any line now operating. Far from being the ultimate in such development, the company reports it expects the installation soon of lines which will approach 3000 fpm. The lines have great speed, flexibility and economy.

10. Vacuum melting and vacuum heat treating are processes which are "coming of age." Previously limited mainly to the experimental and laboratory stages, both are now in commercial operation. Pure steel theoretically has tensile strength of up to 1,000,000 psi. In normal commercial practice these strengths are not even approached, however, laboratory runs of steel melted and heat treated in vacuum do more closely approach this strength. Of particular interest is the SAE 52100 steel for ball bearings which has been so processed and which give life up to four times that of the same type of steel produced by normal commercial practices.

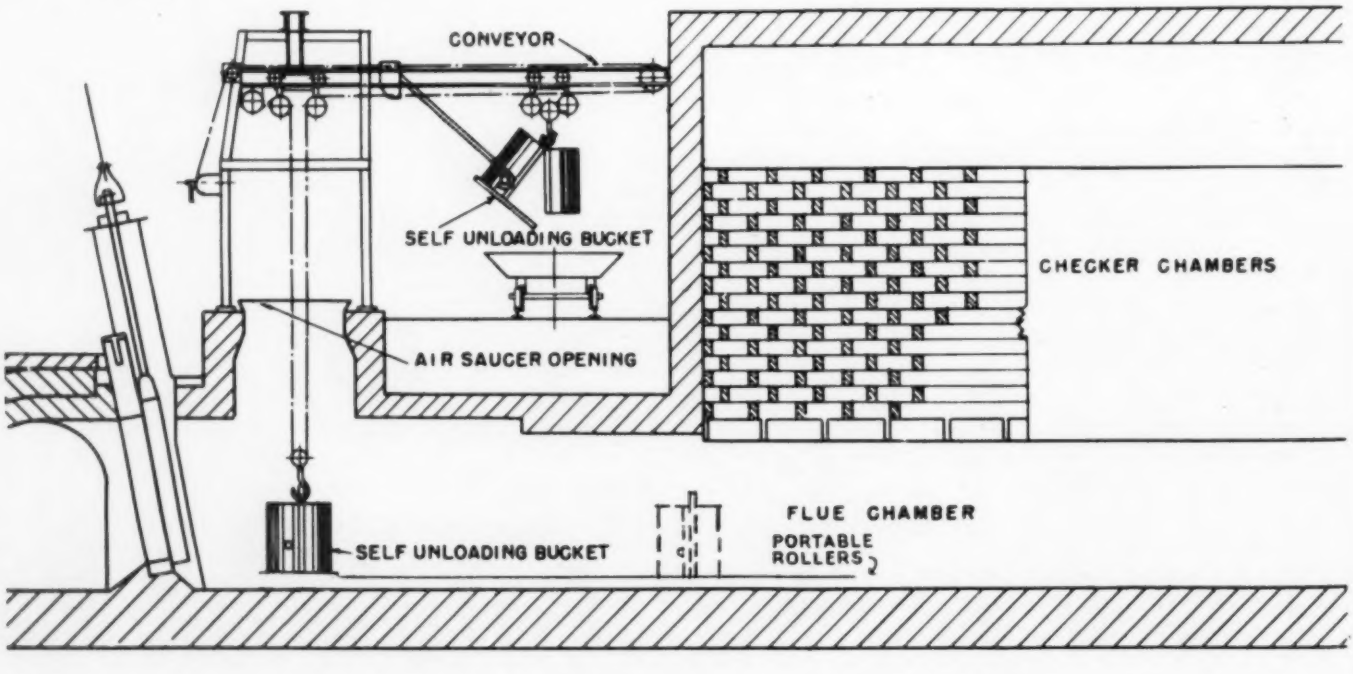
CONVEYOR HELPS IN CLEANING OPEN HEARTH CHECKERS

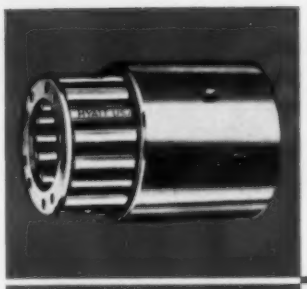
▲ THE Pickard-Warren conveyor, useful in cleaning checker chambers of open hearth furnaces, was designed with the principle of the hayloader as a start. Use of the "hayloader" introduced other problems which were met by designing an automatic tripping device, and automatic self unloading bucket, a frame and safe hook. It was necessary also to apply certain devices, which had already been invented and developed, such as a modification of an Ingersoll-Rand air motor. However, when they were finished the machine was recognized by the U. S. Patent Office with six claims.

The self unloadnig conveyor works as follows: A small beam of aluminum is suspended over the point to which the material is to be raised reaching to the spot where it is to be disposed of. One end is supported by an aluminum frame and the other end is supported by a simple aluminum chain hoist. Having one end suspended from the chain hoist permits one to raise or lower the end for repairs and servicing. A trolley, also of light construction, which operates on the beam, carries a solid bottom, automatic dumping, patented bucket.

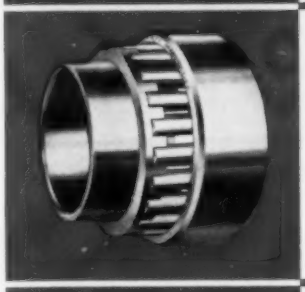
The machine is powered by an Ingersoll-Rand air hoist, Model BU, which has a lifting capacity of 600 lb at 50 fpm. The bucket is raised in a vertical position until the block and hook which hold the bucket engage with the trolley. Then an automatic device causes the trolley to move in a horizontal plane any distance along the beam the operator desires. Attached to and hanging from near the end of the beam are two arms which engage trunnions that extend from the sides of the bucket. As the trolley continues to move while the bucket is being held by the arms, the latches

Figure 1 — Section through flues and checker chambers of open hearth furnace shows operation of bucket used for cleaning.

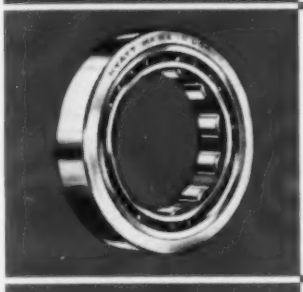




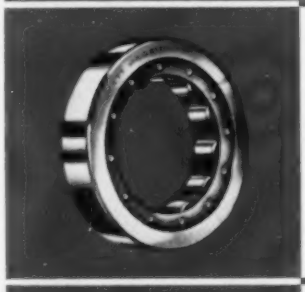
TRUNNIONED ROLLER CAGE—Economical for volume use on thin-annulus bearings. End rings are hardened steel stampings, connected by riveted bars interspersed between rollers to form an integral unit. Races can be omitted if desired.



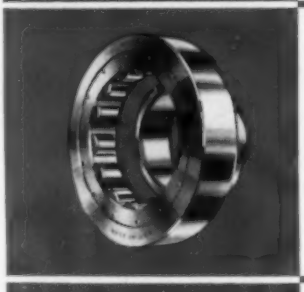
POCKETED END RING CAGE—Designed for fairly large bore bearings in heavy-duty service. Rollers are guided accurately by pockets drilled in bronze end rings. Riveted connecting bars form an integral unit, so races can be omitted if desired.



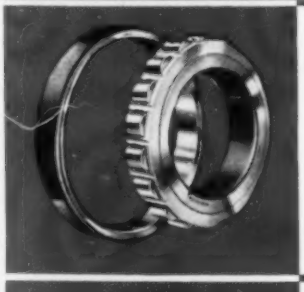
STAMPED STEEL SEPARATOR—Economical for volume use on wide range of bearings with short rollers. A single steel stamping with bars coined to conform to roller contour. Simple, open design assures large lubricant capacity and good circulation.



FORMED BAR CAGE—Well adapted for volume use on heavy-duty bearings. Hardened steel end rings are connected by cold-rolled shaped bars conforming to roller diameter. Insures quiet operation, better roller guidance, and the smooth surface of bars protects rollers.



DRILLED POCKET CAGE—Used on better-grade bearings to provide extremely close control of rollers, which operate in pockets drilled and reamed in bronze cylinder. Riveted ring on one end retains rollers permanently, so races may be omitted if desired.



SEPARABLE BROACHED POCKET CAGE—Used only on finest high-speed bearings. An integral bronze cylinder with pockets broached for maximum uniformity. Insures minimum friction, better oil circulation for cooling. Rollers can be removed for inspection.

NON-SEPARABLE BROACHED POCKET CAGE—Similar to the above and offers all the same operating advantages. Used for "blind" installations where rollers must be retained with inner or outer race. Roller drop controlled by deforming bars after rollers are placed.

What makes a cylindrical roller bearing good?

When you buy a roller bearing, you expect it to do a certain job for you. How well it does that job depends on many different factors. This series of messages is designed to help you recognize some of these important differences and get more for your bearing dollar.

The RIGHT KIND OF RETAINERS for the application

The basic parts of a roller bearing are the rollers, the races, and the *retainer* which locates and guides the rollers. There are significant differences in the design and construction of retainers, which influence bearing cost and performance. Some are simple and economical, well adapted for volume production; others are more costly but insure improved roller guidance, or cooler and smoother operation, or longer heavy-duty service. The seven basic types in current use are illustrated.

HYATT MAKES ALL SEVEN TYPES . . . EACH THE FINEST OF ITS KIND! You will find complete details in HYATT General Catalog No. 150, or your nearby HYATT Sales Engineer will gladly help you choose the type best suited to your requirements. Remember, HYATT is America's *first* and *foremost* maker of cylindrical roller bearings. Hyatt Bearings Division of General Motors, Harrison, N. J.

GM GENERAL MOTORS

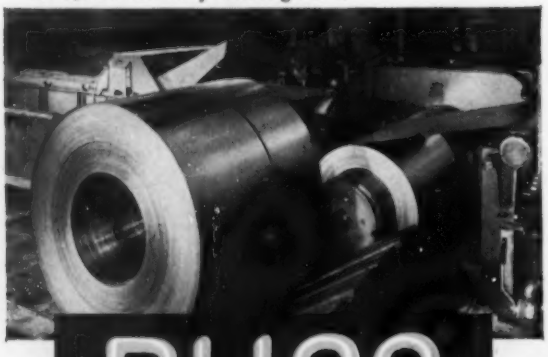
HYATT ROLLER BEARINGS

New coil handling equipment helps Inland Steel boost output of two mills

New Bliss coil handling equipment recently installed on two tandem mills at Inland Steel's Indiana Harbor Works handles coils weighing up to 30,000 pounds. *Former maximum was 20,000 pounds.*

The Bliss installation has also improved output by mechanizing operations like handling the coil end at the entry side and catching it as it whips out of the delivery end.

On both mills—a 72" 3-stand and 54" 4-stand—Bliss reel and horizontal belt wrappers like the one above, provide tight, smooth-edged coils.



Bliss entry equipment on 72" mill handles 30,000-lb. coils, mechanically sticking ends.

This mechanization of steps that used to be heavy and hazardous manual labor has meant greater tonnage per man and improved operator safety.

Inland Steel's experience with these two mills shows how safety improvement and production increases can often be coaxed from existing mill equipment simply by improved methods of handling.

It's likely that you too can crack a hidden bottleneck by consulting Bliss. For information on the Bliss line and what it can do for you, write for your free copy of our 60-page Rolling Mill Brochure, Catalog 40-A.

BLISS
SINCE 1857

is more than a name...it's a guarantee

E. W. BLISS Company, Rolling Mill Division: Salem, Ohio

Plants in Canton, Cleveland, Salem and Toledo, Ohio; Detroit and Hastings, Michigan; Midland and Pittsburgh, Pennsylvania; San Jose, California E. W. Bliss (England) Ltd., Derby E. W. Bliss Co. (Paris), France

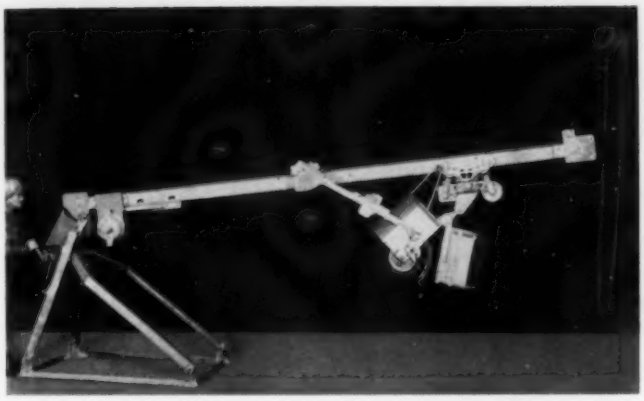


Figure 2 — Wheel on bucket helps in movement.

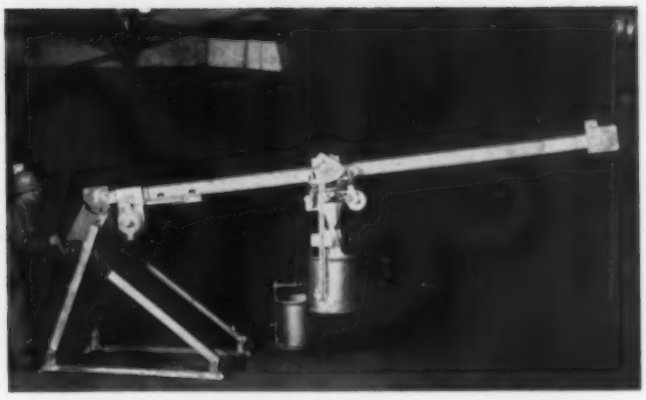


Figure 3 — Air motors are normally used for power.

on the side of the bucket become disengaged which permits the bucket to open up any distance desired by the operator. It is important here to note that the bucket does not depend on the mass of the material within the bucket to open it as in most conventionally designed buckets. In brief, the bucket would open in the same manner whether it was loaded with steel or cotton. The speed with which the bucket opens is again under control at all times, so that if one were dumping a loose matter on a conveyor belt, one could dump it no faster than would be desirable for the efficient operation of the belt conveyor.

It must be kept in mind that during the time the operator pulled the lever on the air hoist to raise it off the floor, he has had to do nothing else to control this operation except shut the air off after the material has been completely dumped. If he forgets to shut the air off, no harm is done, as the bucket will not open any wider and there are no gears or moving parts to break. The air motor merely stalls.

To reverse this operation, the operator pushes the same control in the opposite direction which causes the air motor to reverse. It should be noted here that the air motor does not reverse the trolley, but that the trolley is pulled backwards by two spring loaded reel-lites in tandem. The trolley plays out the cable while in reverse and thus determines the amount of tension the reel-lites can exert to pull the trolley back. Reversing of the trolley permits the bucket to close, at the same time freeing the catch so that it again locks the bucket. When the bucket reaches the rear position of the beam nearest the reel-lites, a knocker causes the trolley to stop its horizontal motion and permits the block to descend with the bucket.

Since the bucket is a flat, solid bottomed bucket, it may be moved about on rollers, wheels which are permanently fastened to the bottom of the bucket, or may be moved about on some type of wagon or other vehicle. These buckets have capacities of three to five cu ft. To raise a load of flue dirt and brick from a hole twenty feet deep and dump it approximately ten feet from the hole and return the bucket to the bottom, requires approximately forty-five seconds.

This conveyor was found to be most helpful in removing a combination of grease and scale which accumulates in the scale pit under a rolling mill, since the bottom of the bucket is literally pulled from underneath the scale and grease while one of the sides opens. Thus there is no possible way for the grease and scale to remain in the bucket. This particular unit was installed three and one-half years ago and is still doing the job.

The conveyor has been used in many plants by this time and has definitely been found to reduce man-hours needed for the job of checker chamber cleaning by fifty to seventy five per cent. It has also been found that "outage time" on open hearth steel furnaces can be reduced. It also contributes to the safety and other welfare of the workers who perform this disagreeable task.

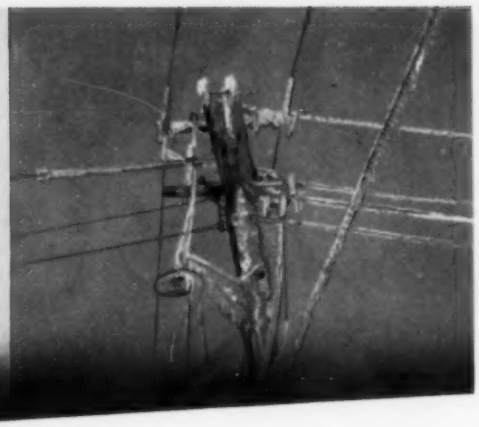
1956

AISE CONVENTION AND EXPOSITION

CLEVELAND PUBLIC AUDITORIUM

CLEVELAND, OHIO

SEPTEMBER 25, 26, 27, 28



When an

ICE STORM CAUSED SINGLE PHASING

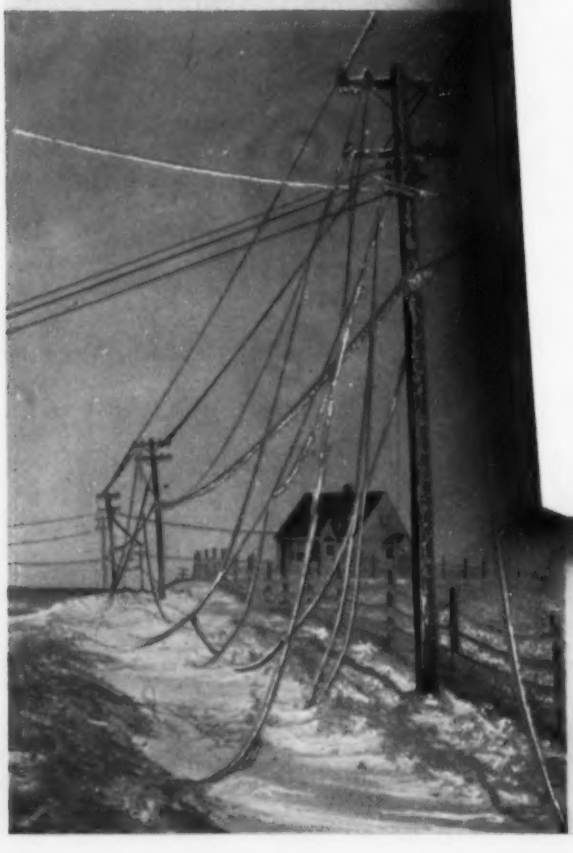
and low voltage conditions . . we blew a flock of Fusetron fuses but we saved over 40 motors from burnout

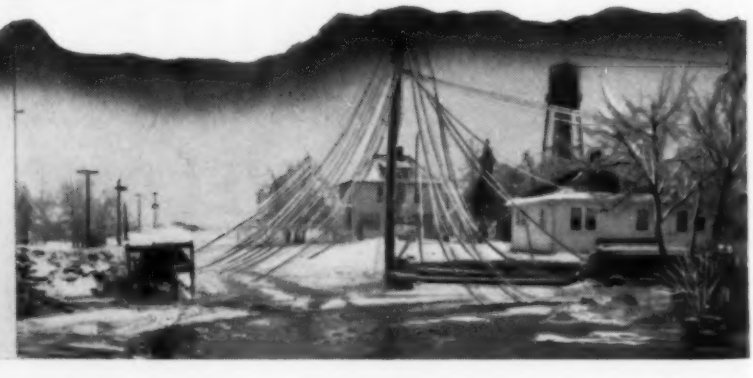
"For twenty-four hours after the bad ice storm of February 15, 1950 we were endangered by single phasing and low voltage conditions due to the damage done the power lines by the ice.

"During this period, we blew a flock of Fusetron dual-element fuses—around 240 in fact—but we figure that was a very cheap price to pay for saving over 40 motors from burning up.

"After this experience we didn't lose any time in putting all of our plant and equipment under Fusetron Fuse protection."

Michael G. Kupcho,
Master Mechanic
Ashland Shirt and Pajama Company
Ashland, Pennsylvania





You too, can be safe from electrical hazards by using

Fusetron DUAL ELEMENT Fuses

They provide 10 Point Protection

1 High interrupting capacity—protect against heaviest short-circuits. Have proven on tests to open safely on circuits set to deliver in excess of 100,000 amperes.

2 Protect against needless blows caused by harmless overloads.

3 Protect against needless blows caused by excessive heating—lesser resistance results in cooler operation.

4 Provide thermal protection — for panels and switches against damage from heating due to poor contact.

5 Protect motors against burnout from overloading.

6 Protect motors against burnout due to single phasing.

7 Give DOUBLE burnout protection to large motors — without extra cost.

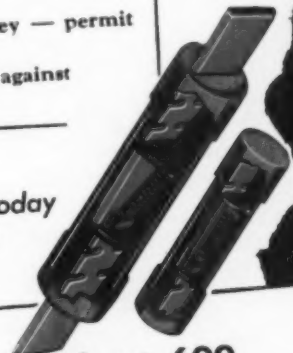
8 Make protection of small motors simple and inexpensive.

9 Protect against waste of space and money — permit use of proper size switches and panels.

10 Protect coils, transformers and solenoids against burnout.

Write for bulletin FIS.

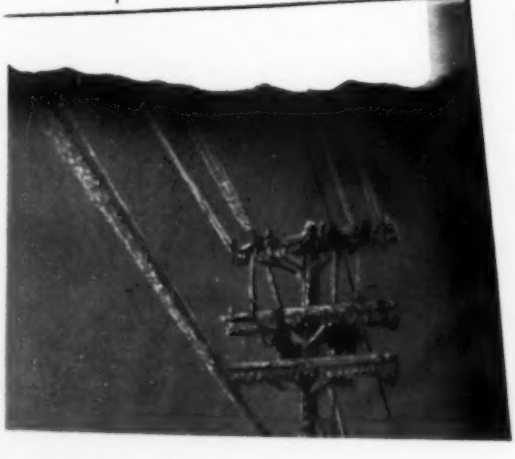
DON'T RISK LOSSES — *Start today to install FUSETRON fuses throughout the entire electrical system!*



FUSETRON

TRUSTWORTHY NAMES IN ELECTRICAL PROTECTION

BUSS



For loads above 600 and up to 5,000 amps., . . . use BUSS Hi-Cap Fuses . . .

They have unlimited interrupting capacity to handle any fault current regardless of system growth.

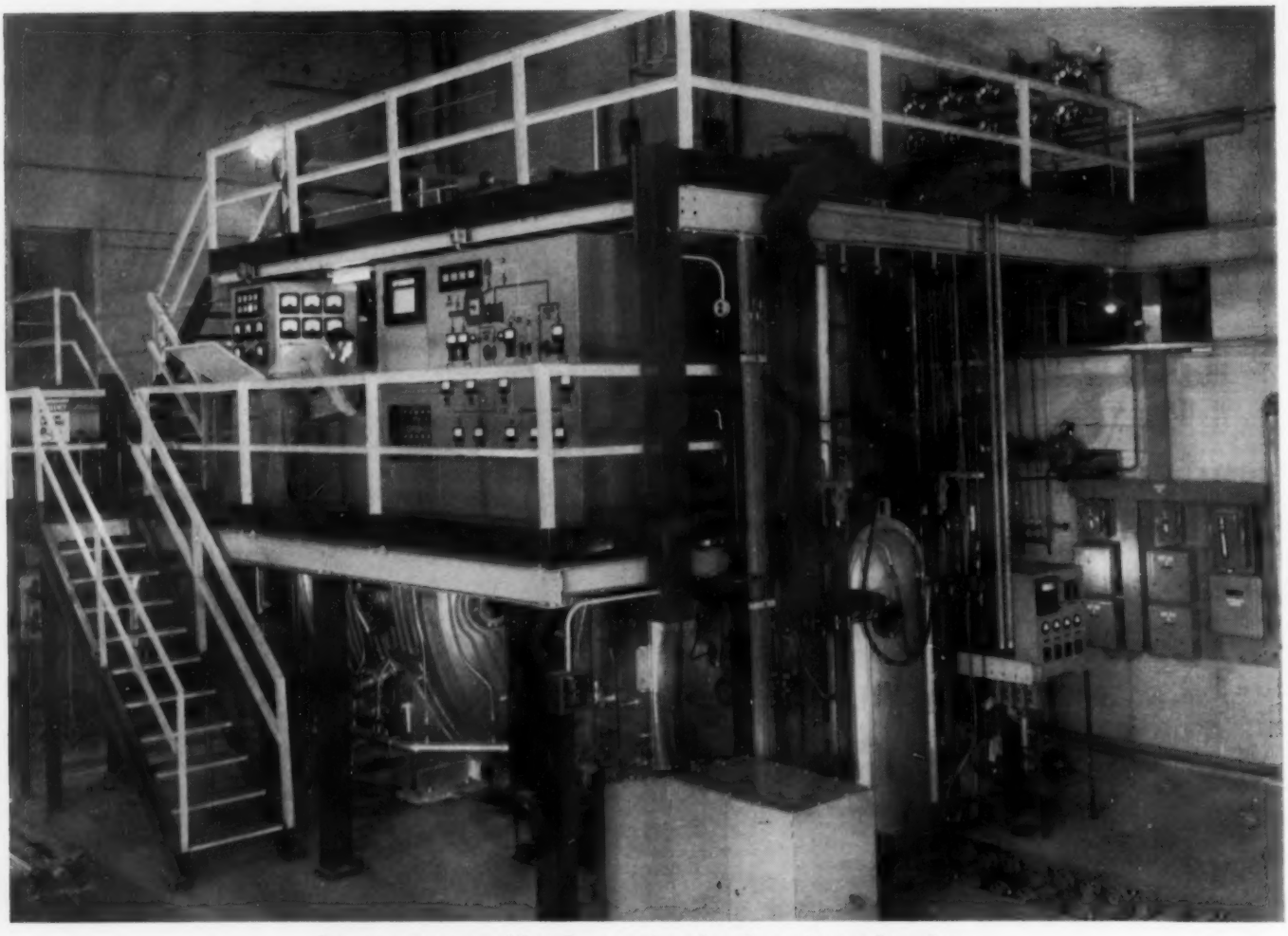
Overload protection as well as short-circuit protection.

Coordinated with Fusetron fuses on feeder and branch circuits to limit fault outages to circuits of origin.

Dependable service through the years because there are no moving parts to stick or get out of order.

Write for bulletin HCS.

BUSSMANN MFG. CO. (Div. of McGraw Electric Co.) St. Louis 7, Mo.



Large vacuum melting furnace taps ingots up to one long ton.

Vacuum Furnace Reaches One-Ton Class

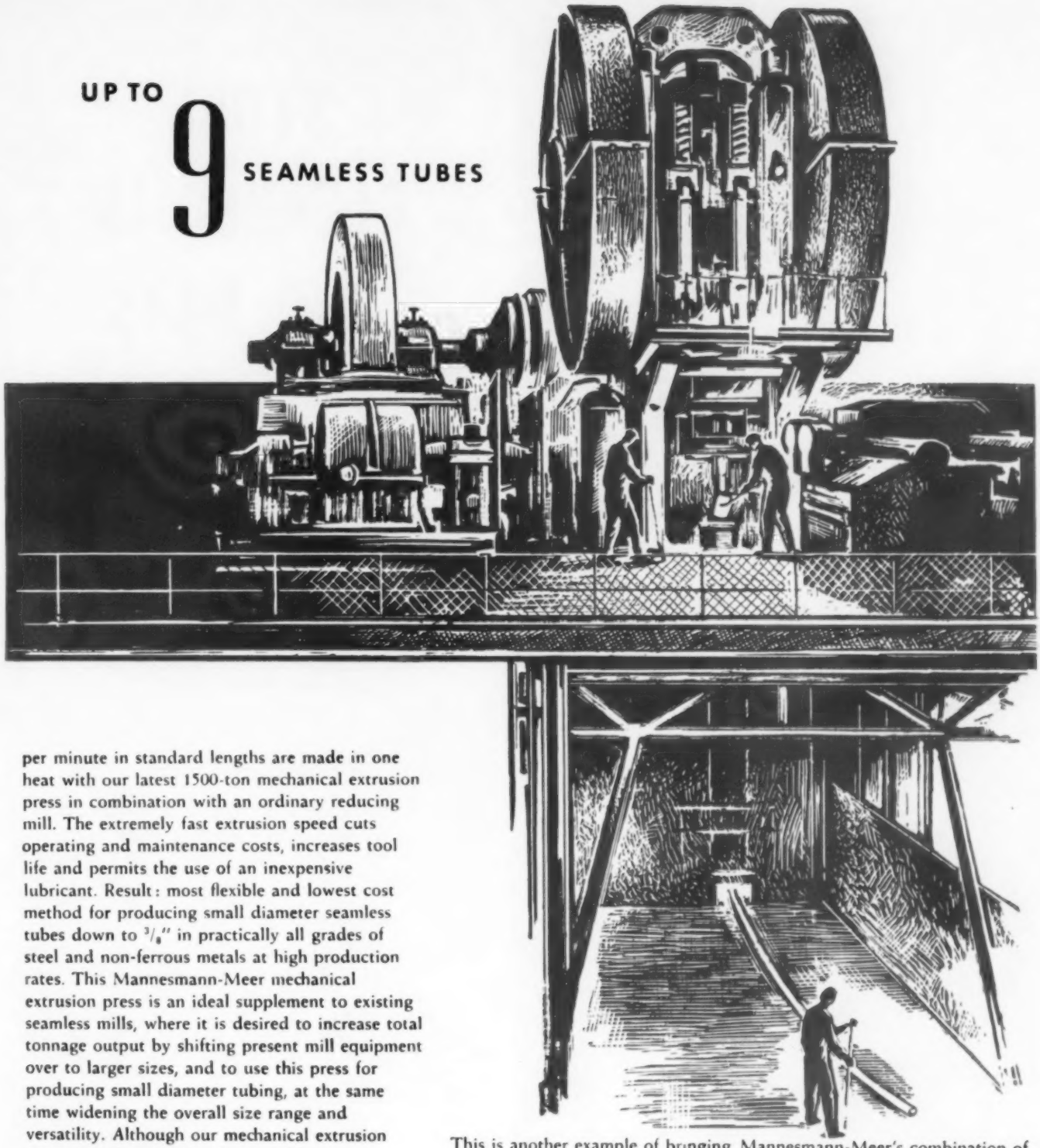
▲ WHAT is up to now, the nation's largest vacuum melting furnace was put into operation at Syracuse, N. Y., by Vacuum Metals Corp.

Dwarfing the earlier 300 and 600-lb furnaces, the new 2200-lb vacuum melting furnace is a far cry from the small crucibles that produced the first samples of vacuum melted metals in the laboratories of National Research Corp. more than ten years ago. This new furnace is remotely operated by the melter, who can control from one console the charging, mold transfer, and pouring operations. The melting unit is enclosed in a ¾-in. thick airtight and liquid-cooled stainless steel chamber, with connecting air lock chambers for charging raw materials and discharging ingots. The design makes it possible to charge, melt, pour and remove ingots without affecting the vacuum in the melting chamber. The mold handling mechanism makes it possible to cast ingots of varying size and shape, either singly or in multiples from a single heat.

The design, which was based on five years of operating experience with such semi-continuous vacuum furnaces, was under the direction of Dr. M. H. Hnilicka of the research division of National Research Corp. The furnace was built by the equipment division of National Research and installed by the engineering department of the Sanderson-Halcomb Works of Crucible Steel, under the direction of Mr. W. K. Lowe, chief engineer. The new unit increases by 60 to 75 tons, the monthly potential supply of vacuum melted metal for industry.

The products of this process are characterized by cleanliness and low gas content, with consequent higher elevated temperature strength and ductility, and increased fatigue and impact strengths. They have proven superior for use in critical applications in aircraft engines and in machinery components requiring a quality unattainable from conventional metal.

UP TO **9** SEAMLESS TUBES



per minute in standard lengths are made in one heat with our latest 1500-ton mechanical extrusion press in combination with an ordinary reducing mill. The extremely fast extrusion speed cuts operating and maintenance costs, increases tool life and permits the use of an inexpensive lubricant. Result: most flexible and lowest cost method for producing small diameter seamless tubes down to $^3/_8$" in practically all grades of steel and non-ferrous metals at high production rates. This Mannesmann-Meer mechanical extrusion press is an ideal supplement to existing seamless mills, where it is desired to increase total tonnage output by shifting present mill equipment over to larger sizes, and to use this press for producing small diameter tubing, at the same time widening the overall size range and versatility. Although our mechanical extrusion presses are in operation for over 25 years, continuous development is incorporated in today's press design to match present and future operating requirements.

This is another example of bringing Mannesmann-Meer's combination of

- CREATIVE ENGINEERING
- DESIGN EXPERIENCE
- OPERATING BACKGROUND
- AMERICAN MANUFACTURING SKILL

to bear on your tube mill problems.

MANNESMANN-MEER

ENGINEERING AND CONSTRUCTION COMPANY, 900 LINE STREET, EASTON, PENNA

WORLD SPECIALISTS IN HIGH-SPEED TUBE MILL MACHINERY

STOVE CLEANED IN TWO DAYS

DOWELL chemical cleaning increased time stove could be kept on furnace by 66%

The operator of this blast furnace stove had a problem. One like it may face you. He knew the modern solution. Do you?

His problem: From 14 to 19 feet of brick spalls and flue dust had accumulated on top of the ball inserts in the checkers, cutting time on the furnace drastically. He had to increase that time, yet he didn't want to take the stove out of operation for the long period required by mechanical cleaning.

His solution: He called Dowell engineers to clean the checkers chemically. Using special headers, they washed the flues with solvents in just 2½ hours. After overnight soaking, all 1,000 checkers were jetted in 5 hours with high-pressure water. Plugging materials were disintegrated. Total cleaning time—two days.

His results: After Dowell cleaning, the stove could hold 1200°F. for more than 2½ hours on the furnace . . . compared to 950°F. for only 1½ hours before. Efficiency was restored at minimum expense, in minimum downtime.

A regular schedule of Dowell chemical cleaning in *your* plant may pay for itself many times over . . . in greater production efficiency, longer equipment life, less outage time, lower maintenance cost. Find out! Call the Dowell office near you. Or write Dowell Incorporated, Tulsa 1, Oklahoma, Department A-29.

chemical cleaning service for industry

DOWELL

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

Date-line Diary...

December 2

▲ Westinghouse Electric Corp. slashed executive salaries as much as 50 per cent as part of its program of cutting costs during their labor troubles.

▲ The Aluminum Co. of Canada is reducing output in Quebec by 5 per cent because a drought during the summer curtailed electric power supplies.

▲ According to Thomas B. McCabe, president of Scott Paper Co., industry will require a minimum of $160,000,000,000 in public financing in the next ten years, over double the total in the past decade.

▲ Armco Drainage and Metal Products, a subsidiary of Armco Steel Corp., plans erection of a $1,500,000 plant at Middletown, Ohio, to turn out a complete line of pre-fabricated steel buildings.

▲ Conoflow Corp. will become a subsidiary of the Walworth Co. under an exchange-of-stock agreement between the two companies.

▲ The Aluminum Assn. reported primary production of aluminum during October totaled 269,312,211 lb in comparison with 261,211,002 lb in the previous month and 250,178,989 lb in October 1954.

December 5

▲ Kaiser Aluminum launched a $280,000,000 expansion program to increase its aluminum-making capacity by over 50 per cent, or to 654,000 tons yearly.

▲ Follansbee Metals Corp. announced the sale of the last two of three steel storage and processing warehouses it has operated since last December. These were the last of the assets owned by Follansbee Steel Corp.

▲ Jones and Laughlin Steel Corp. announced increases in extras for hot and cold rolled sheets ranging from 5 to 20 cents per 100 lb.

▲ The AISI reports that the operating rate of the steel industry for the week of December 5 is scheduled at 98.8 per cent of capacity. This is equivalent to 2,384,000 tons compared with 2,356,000 tons one week ago and 1,958,000 tons one year ago. Index of production for the week is 148.4.

December 6

▲ The AISC reported October bookings of fabricated structural steel amounted to 308,780 tons compared to 339,461 tons in September and 213,497 tons in October one year ago. Shipments in October totaled 283,768 tons leaving a backlog of work ahead as of October 31 of 1,927,811 tons.

▲ The Defense Dept. issued a new directive allowing higher payments under military contracts worth about $3,000,000,000 yearly which allows profits of around 8 to 10 per cent compared with the previous 5 per cent allowed last summer.

December 7

▲ Steel scrap gained $1 to $3 a ton in Chicago. Small sales of the No. 1 scrap were reported at $48 a ton, $3 above the previous transaction. At the beginning of the year this scrap was $33 to $34 per ton.

▲ Business inventories at the end of October were 5 per cent above the year-earlier level with sales for this period being 14 per cent above the year-earlier level. The Commerce Dept. also stated that stocks rose to $81,300,000,000 or $1,600,000,000 above September.

▲ Armco Steel Corp. announced it has revised price on extras of carbon sheet materials, similar to the raises of Jones and Laughlin.

December 8

▲ Business outlays indicate that 1956 first quarter capital expenditures will run at an annual rate of $31,600,000,000 which is 12 per cent above the year-earlier level.

▲ Personal income reached an annual rate of $309,600,000,000 during October, according to the Commerce Dept. This was $1,700,000,000 above the September pace and $21,200,000,000 above the yearly rate in October one year ago.

▲ Electricity output last week amounted to 11,300,000,000 kwhr which was 210,000,000 kwhr above the previous record reached 14 days earlier and 18.2 per cent better than the corresponding week for 1954.

▲ Employment in November totaled 64,807,000 which was 2,600,000 above this period for 1954 but down 86,000 from October.

▲ Broker prices indicate steelmakers would have difficulty in getting No. 1 scrap at less than $49 per ton. This would be $2 above previous transactions.

December 9

▲ Construction outlays in the first 11 months of 1955 have already exceeded the previous record set in the full year 1954 of $37,600,000,000.

▲ Consumption of scrap and pig iron during October totaled 12,635,000 gross tons, an increase of 6 per cent over September's total of 11,963,681 gross tons, according to The Bureau of Mines, United States Dept. of the Interior. Scrap consumed in October totaled 6,443,000 tons.

▲ The AISI reported payroll total for the iron and steel industry for the first ten months of 1955 totaled $2,940,870,000 or about $32,500,000 above the estimated payroll for all of last year. The October average hourly payroll cost of wage earners was $2.60 for each hr worked compared with $2.602 in September and $2.364 in October of 1954. Fringe benefits now add an additional 20 cents per hr. In October, employment was 644,039 and wage earners averaged 39.5 hr a week.

▲ According to the ARCI, new freight car orders in 1955 are expected to total around 161,800, the largest figure in over thirty years. Of this, only 15,500 were ordered in the first five months of the year. Backlog at the end of the year was about 145,000 cars. Production in 1955 was 38,000 cars.

December 12

▲ The F. W. Dodge Corp. reported contract awards for future construction in the 37 states east of the Rockies in November totaled $1,796,787,000 up 20 per cent above November of 1954.

▲ The AISI reports that the operating rate of the steel industry for the week of December 12 is scheduled at 99.3 per cent of capacity. This is equivalent to 2,397,000 tons compared with 2,416,000 tons one week ago and 1,950,000 tons one year ago. Index of production for the week is 149.2.

December 13

▲ Railroads were advised, by an emergency board named by President Eisenhower, to grant 750,000 non-operating employes a wage increase package of 16½ cents per hr.

▲ Koppers Co. has acquired 80 per cent of the common stock of Durethene Corp. in Chicago and Los Angeles. This company produces polyethelene film and tubing.

December 14

▲ The Texas Co. plans to spend a record $1,500,000,000 over the next five years on improvements and expansion of its facilities.

December 15

▲ Copper production was halted at three U. S. owned mines in Chile as 16,000 employees walked out. News of this strike caused a rise in price to $0.50⅝ per lb in London.

▲ The AEC awarded the Babcock and Wilcox Co. its first contract to a private plant for the production of atomic reactor fuel elements.

December 16

▲ General Electric Co. expects a jump of 10 to 15 per cent in 1956 sales and plans to spend $500,000,000 in new facilities over the next three years to meet expected rise in sales.

▲ The Labor Dept. reported home building in November dropped to the lowest level of the year. Housing starts declined to 89,200 units which was about 3 per cent below the pace set in the two preceding months.

▲ Rail shipments of steel products from the Allegheny area during the first quarter of 1956 will increase nearly 20 per cent over the corresponding quarter in 1955 predicts the Shippers Advisory Board.

▲ Texas Eastern Transmission Corp. filed an application with the Federal Power Commission for authorization to construct a new 30-in. pipeline from Beaumont, Texas to McAllen, Texas, and expansion of 30-in. system from Beaumont to New Jersey.

▲ Kaiser Motors Corp. plans to diversify its operations and change its name to Kaiser Industries Corp. It also plans to stop producing passenger cars and confine itself to making Jeeps. Henry J. Kaiser Co. will become a subsidiary company.

December 19

▲ The Aluminum Assn. reported primary aluminum production in November totaled 267,377,623 lb in comparison with 269,312,211 lb in October and 242,503,923 lb in November 1954.

▲ The AISI reports that the operating rate of the steel industry for the week of December 19 is scheduled at 97.5 per cent of capacity. This is equivalent to 2,353,000 net tons compared with 2,421,000 tons one week ago and 1,726,000 net tons one year ago. Index of production for the week is 146.5.

December 20

▲ The 16,000 strikers at the three American-owned copper mines in Chile were given 48 hours to return to work or be called to military duty.

▲ The U. S. Dept. of Commerce announced that shipments of iron and steel castings during September amounted to 1,481,000 short tons or 3 per cent above the August total and 39 per cent above shipments in September 1954.

▲ By mid-December, Chrysler Corp.'s 1955 total production reached an all-time record of 1,403,748 vehicles including 1,310,770 cars and 92,978 trucks.

December 21

▲ According to Defense Dept. secretary, Mr. Wilson, defense spending will go up around $1,000,000,000 in the fiscal year beginning July 1, 1956.

▲ Pennsylvania Railroad's net in November was 17 per cent under the November 1954 net, but despite this drop, the net for the first 11 months of 1955 was the largest since 1945.

▲ Deliveries of new domestic freight cars in November showed a slight decrease to 3427 from 3772 in October and 1302 cars in November 1954, according to the ARCI. Orders in November totaled 51,066, a new record high, compared with 12,843 in October. Backlog of cars on order as of December 1 stood at 109,370.

▲ According to the U. S. Rubber Co. president, H. E. Humphryes, Jr., rubber industry sales for 1956 will top $5,700,000,000 which is about $500,000,000 above this year's volume.

▲ A 100 per cent common stock dividend was declared by Continental Can Co., on its common.

▲ According to R. S. Reynolds, Jr., president of Reynolds Metals Co., more aluminum will be used in 1956 than ever before or about 3,300,000,000 lb. The 1955 year exceeded all expectations and set a new record with production reaching 3,100,000,000 lb.

December 23

▲ U. S. Steel Corp. and its Columbia-Geneva Steel Div. and Tennessee Coal and Iron Div., announced a change in product classification and pricing of hot rolled carbon steel bars.

▲ A proposal to boost Alan Wood Steel Co.'s long-term debt limit to $9,750,000 from the $7,000,000 was defeated at a special meeting when it failed to win approval of two-thirds of the preferred stock.

December 25

▲ Merry Xmas.

December 26

▲ The AISI reports that the operating rate of the steel industry for the week of December 26 is scheduled at 95.0 per cent of capacity. This is equivalent to 2,292,000 tons compared with 2,338,000 tons one week ago and 1,850,000 tons one year ago. Index of production for the week is 142.7.

December 27

▲ Cleveland-Cliffs Iron Co. raised prices on iron ore for shipments in the 1956 season about 8 per cent or $0.85 per ton.

December 28

▲ The AISC reports November bookings of fabricated structural steel amounted to 345,308 tons compared to 308,780 tons in October and 195,550 tons in November 1954. Shipments in November totaled 258,883 leaving a backlog of work ahead as of November 30 of 2,075,465 tons.

▲ Railroads asked the ICC to suspend existing rules and allow them to seek rate boosts averaging 7 per cent under a speeded-up procedure.

December 29

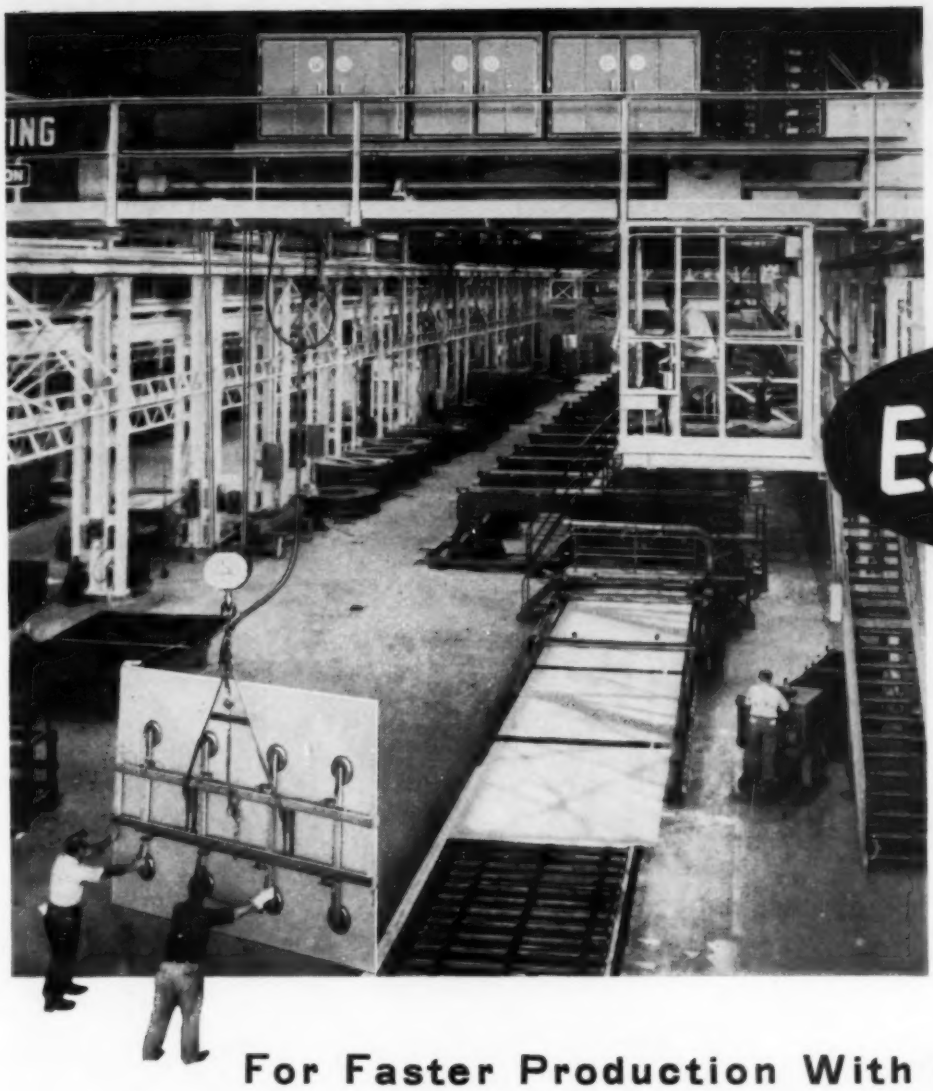
▲ At special meetings, stockholders, of Square D Co. in Detroit and Electric Controller and Manufacturing Co. in Cleveland, voted to approve the proposed merger of the two companies. An exchange of 1½ shares of Square D capital stock for each share of Electric Controller stock is planned.

▲ Rotary Electric Steel Co. listed 740,700 shares of common stock, par $10, on the New York Stock Exchange, of which 696,700 shares are outstanding and 44,000 additional shares are to be issued from time to time.

December 30

▲ Lead advanced ½ cent a lb to 16 cents in New York.

▲ The Edison Electric Institute estimated that utilities plan to step up spending for new plant and equipment in 1956 to a record $2,900,000,000 which is $24,000,000 above the amount spent in 1953.



Easy does it...

with EC&M *ENGINEERED* CRANE CONTROL

One of several EC&M Controlled cranes which serve the grinding and polishing lines in a glass manufacturing plant. EC&M Control permits slow even speeds . . . as workmen walk along and guide the load . . . as glass is gently lowered onto the work tables.

For Faster Production With Greater Safety

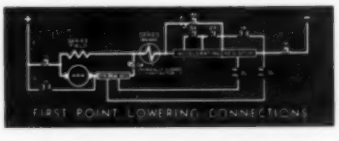
Your crane control is developed by EC&M from the crane data sheet. From gearing, rope reeving, motor loading and similar data, EC&M coordinates the control components to give the desired speed regulation that results in smooth performance . . . right from the start.

Before buying your next crane, call the nearest EC&M office and ask for a demonstration. They'll be glad to provide you with an opportunity to climb aboard and operate an EC&M controlled crane. Remember . . . EC&M control equipment assures precise performance for both old and new cranes . . . and performance is proof.

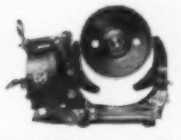
THE ELECTRIC CONTROLLER & MFG. CO.

4498 Lee Road • Cleveland 28, Ohio

Quick-responding Crane Controller with LINE-ARC Contactors and TIME-CURRENT Acceleration

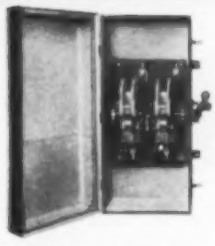


EC&M simplified Wright Circuit provides safe hoist operation



"WB" Brake provides long life and high speed operation

Youngstown Safety Limit Stop eliminates over-hoisting accidents



Manual-Magnetic Disconnect Switch has high interrupting capacity . . . provides remote control

Dependable

...more overhead crane users place their faith in P&H than any other brand

Dependable? P&H Overhead Cranes *have* to be dependable. And we make sure they are!

Every time we install a P&H Overhead Crane we accept the responsibility of keeping that business running, shift after shift, day after day, year after year. If *any* crane breaks down, even in its tiniest part, production suffers, men are out of work, and the word "downtime" begins to appear in the supervisor's reports.

Fortunately, P&H Overhead Crane users aren't familiar with the word.

Proof? Well, for example, there are over 1500 P&H Overhead Cranes — built more than 50 years ago — that are still in dependable service.

The best time to call us in on your overhead crane job, is right at the beginning — at the very inception of the building you have in mind. Our experienced engineers will be glad to work with your men. Naturally, there is no charge for this service.

In the meantime, if you want to dream of the day *your* business will own a P&H Overhead Crane, send for our complete file of free catalogs and literature.

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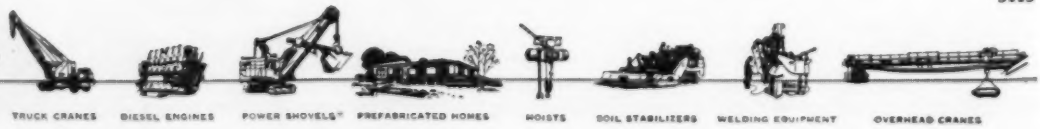
the P&H Line



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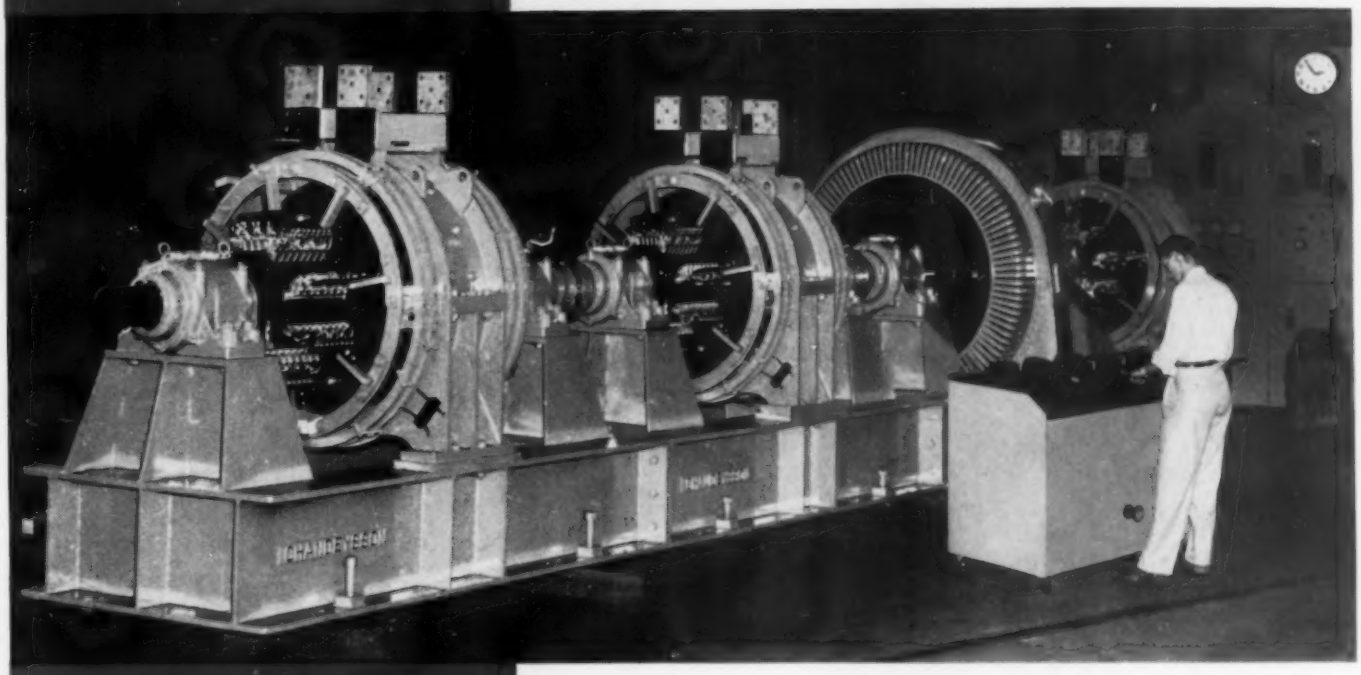
IT HAPPENS AFTER MIDNIGHT...



Chandeysson

MOTOR GENERATORS
are tested relentlessly to assure you a top-efficiency, low-voltage power supply

Before leaving our plant, each Chandeysson generator is run for at least 12 hours at 110% of voltage and 115% of current . . . simultaneously. Performance data is scrutinized by skilled engineers using the most modern electrical testing equipment.

Testing such as this is one reason for the remarkable dependability and high efficiency of Chandeysson equipment. In addition, unified responsibility for the manufacture of every component . . . from selected raw materials to the finished product . . . is in the hands of skilled men who have decades of experience in building low-voltage generators. Our aim in engineering is to *eliminate* design defects . . . rather than to correct for them. This is why more and more "Steel Industry Leaders Choose Chandeysson!"

MAKE US PROVE to you that a Chandeysson Motor Generator set is your most economical and dependable source of low-voltage dc . . . for tinning or any other electrolytic purpose. Mail this coupon today . . .

CHANDEYSSON ELECTRIC COMPANY
4076 Bingham Avenue, St. Louis 16, Mo.

Please send steel mill bulletin.

Name ..... Title .....

Company .....

Address .....

City ..... Zone ..... State .....

CHANDEYSSON ELECTRIC COMPANY 4076 Bingham Avenue, St. Louis 16, Missouri

78

You can pull these plugs at full load . . . SAFELY!

Circuit-Breaking Arktite

PLUGS AND RECEPTACLES

20 amp to 400 amp.—250V D.C.; 600V A.C.

SAFE at all times—even if you pull an *Arktite* plug to disconnect an energized motor or appliance in an emergency!

You don't have to open the disconnect switch before withdrawing an *Arktite*. Arcs created as line and load poles disengage are confined in deep, insulated arcing chambers—are instantly snuffed out by pressure-deionization and lack of oxygen. There's no possible danger of flashover injuring personnel or destroying property.

Contact your Crouse-Hinds Distributor, nearest Crouse-Hinds Office or Representative for complete information.

NEW, Re-Designed *Arktites*...

Feature new pressure connectors — new easier-to-wire 1-piece interior assemblies — new easier-to-interchange plug and receptacle interiors — new plug adaptability to any type and size cable.

Fully interchangeable with older style. Same price. Currently available in 30 and 60 amp. sizes, in 2-, 3- and 4-poles.

● **Operated like a giant switchboard, this *Arktite* installation with variations in power, frequencies and voltages is used to speed up machine tool testing. Plugs can be inserted and withdrawn from "live" receptacles without using a disconnect switch.**

A NATIONWIDE DISTRIBUTION exclusively through ELECTRICAL DISTRIBUTORS

CROUSE-HINDS COMPANY

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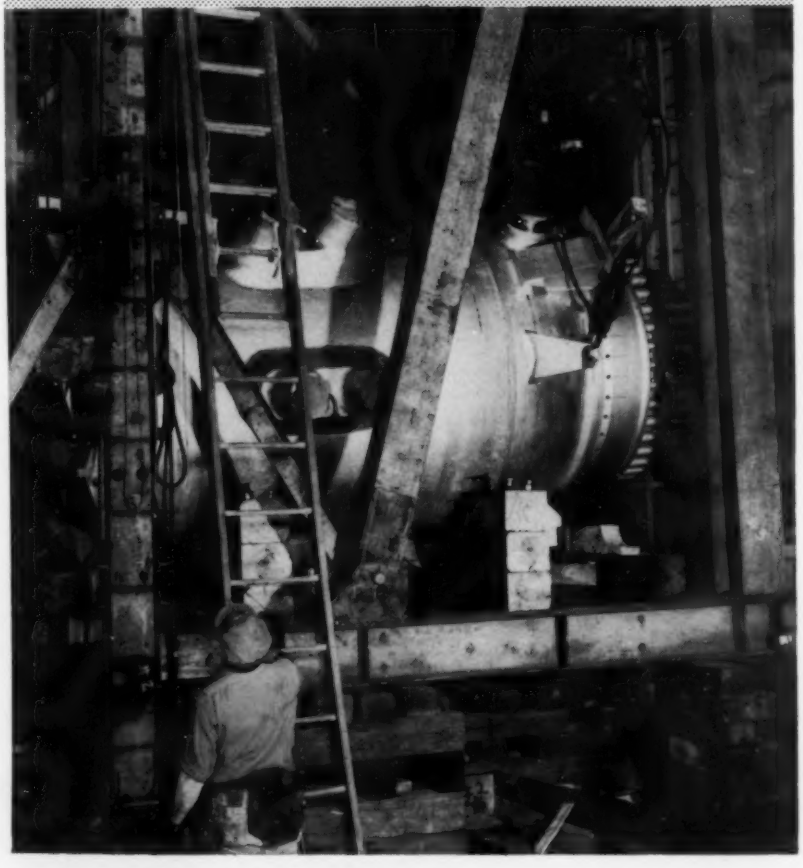
Eichleay... *and the Atomic Age*



The job of unloading, handling and installing the 'Bettis Test Facility' and associated equipment at the Atomic Energy Commission's Bettis Plant, operated by Westinghouse Electric Corporation, called for a degree of skill, precision and finesse seldom encountered in the construction field.

The construction of this equipment made it difficult to handle in a normal manner due to the danger of placing undue stresses on a machine designed to such a high degree of precision. The installation called for tolerances seldom encountered in the construction field and attained only by the use of instruments normally used by physicians and skilled technicians.

Eichleay Corporation with its vast experience in the handling of complex problems made the installation with its usual efficiency and without incident.

Thru the Bettis Test Facility Westinghouse was able to complete development work critical to the "Nautilus" power plant.

EICHLEAY SERVICES

Industrial Installations
Construction of Heavy Foundations
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ESTABLISHED 1875

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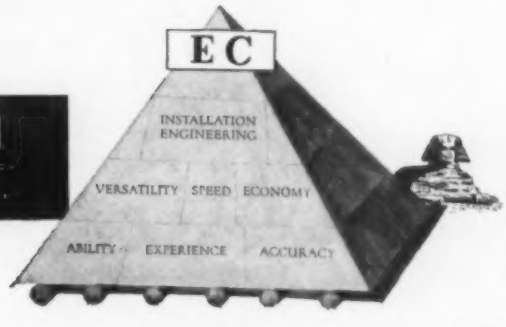
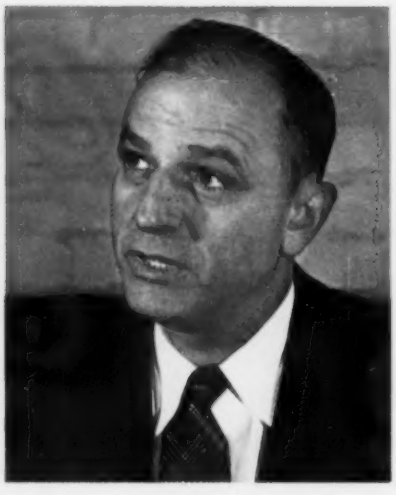


"A Tough Job Today—*Routine Tomorrow*"

says
R. O. Thomas
U. S. Steel's
Forging
Superintendent



THE PICTURE SHOWS the very heart of a horizontal extrusion press being built by the Loewy Construction Company for the Air Force heavy press program. It is the press container—forged, machined and assembled at the U.S. Steel Homestead Forgings Division.

It is the container which must sustain the high pressures exerted on the hot billet as it is forced through a die to form the extruded shape. In extruding an aluminum alloy, for example, the container itself is electrically heated to above the 800° F temperature of the billet—hot enough to soften ordinary steels.

This container is made by shrinking together several steel sleeves, similar to the way big naval guns are constructed. The result is an extremely strong assembly without undue bulk, able to withstand the tremendous pressure exerted during extrusion. The liner (the highly polished inside part), primarily a heat resistant member, is forged from tungsten-chromium-molybdenum-steel, heat treated to a very high hardness to resist deformation. Over this liner is a heavy forged alloy steel liner holder. Next come five forged alloy steel rings that build the total outside diameter to over six feet.

When this press was first proposed, some segments of the industry felt that it would be most difficult, if not impossible, to meet the specifications. In answer, the first units have been shipped from the Homestead Forgings Division after passing all requirements . . . and more units are on the way.

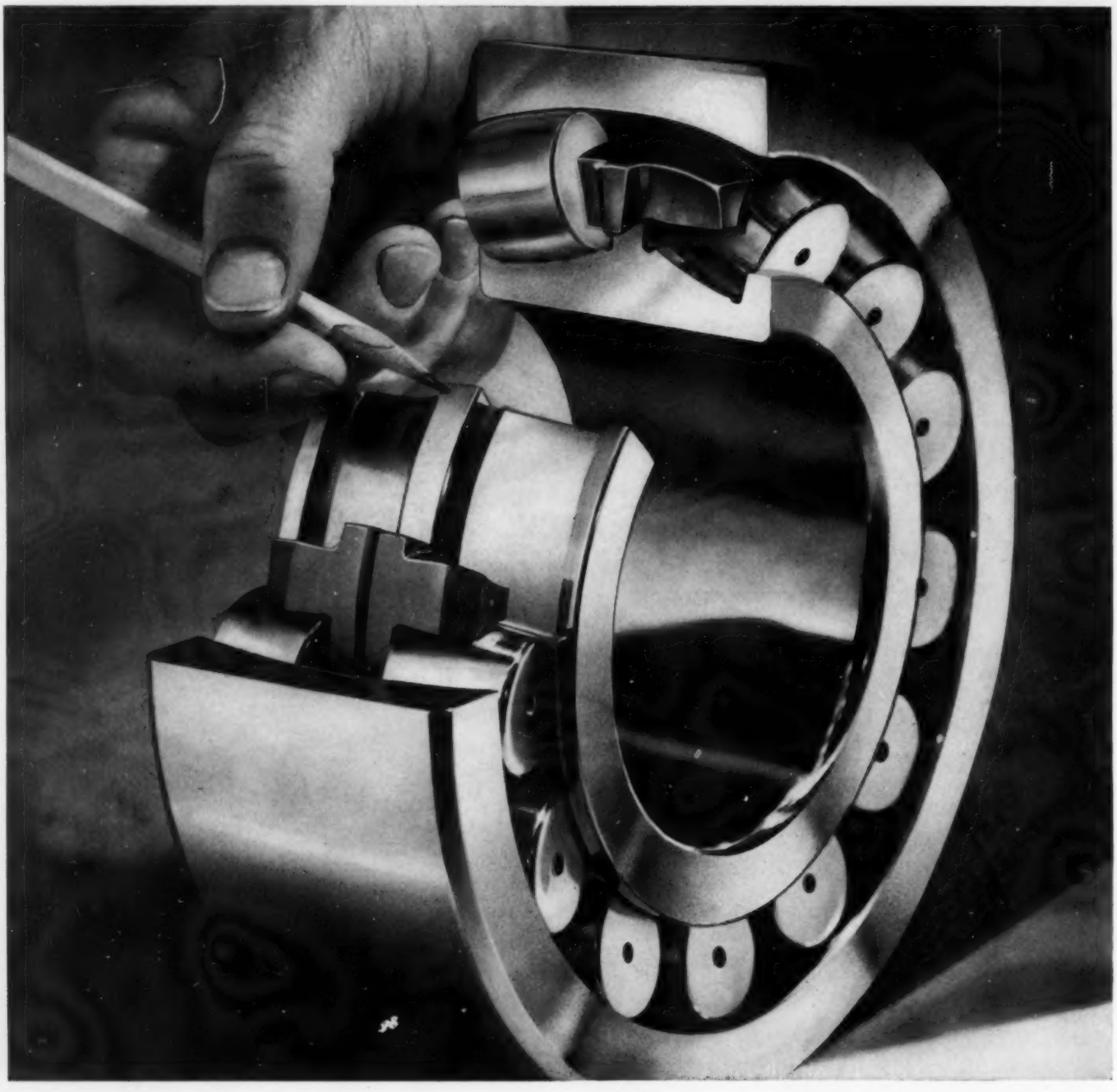
If you would like a free copy of our 32-page booklet that gives the background of USS Quality Forgings, write to United States Steel, Room 5089, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

SEE THE UNITED STATES STEEL HOUR. It's a full-hour TV program presented every other week by United States Steel. Consult your newspaper for time and station.

UNITED STATES STEEL

USS
Quality
FORGINGS
heavy machinery parts — carbon, alloy, stainless
forged steel rolls and back-up roll sleeves
electrical and water wheel shafts
hammer bases and columns

TORRINGTON *SPHERICAL ROLLER* BEARINGS



"This flange guides the rollers to peak performance!"

The center flange on the inner raceway of the TORRINGTON Spherical Roller Bearing positions the rollers to handle thrust loads. This accurate positioning also assures radial stability of the rollers under heavy loads—even at continuous high speeds and under conditions of misalignment.

This superior design feature is only one of many advantages you get when you specify TORRINGTON. For example, you get the service of TORRINGTON'S experienced engineers, who will help you with design and maintenance problems—or design custom bearings for special applications.

For long, low-maintenance service in heavy-duty applications, order TORRINGTON Spherical Roller Bearings. They're available from stock with either straight or tapered bore, for shaft or adapter mounting.

THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.
District offices and distributors in principal cities of United States and Canada

90th ANNIVERSARY 1866–1956

TORRINGTON BEARINGS

Spherical Roller • Tapered Roller • Cylindrical Roller
Needle • Ball • Needle Rollers

HERE'S THE USG® BRUSH THAT DOES AN OUTSTANDING JOB ON ALL YOUR MILL MOTORS

When you replace the brushes on your mill motors, you can get the best results with U S G Grade 135 Brush with Statite®. For brushes that give superb results in other applications, see below. Write for your copy of the complete U S G Brush catalog today.

A typical U.S.G. Grade 135 Mill Motor Brush with Statite*

U S G Grade 1658 Brush for tin line collector rolls

U S G Grade 223 Brush for DC crane motors with Statite*

U S G Grade AH897 Brush for welding generators with Statite*

U S G Grade 550 for AC Crane Motor Rings

Permanent shunt connection, needing no hammerclips; cannot be jarred loose or pulled out.

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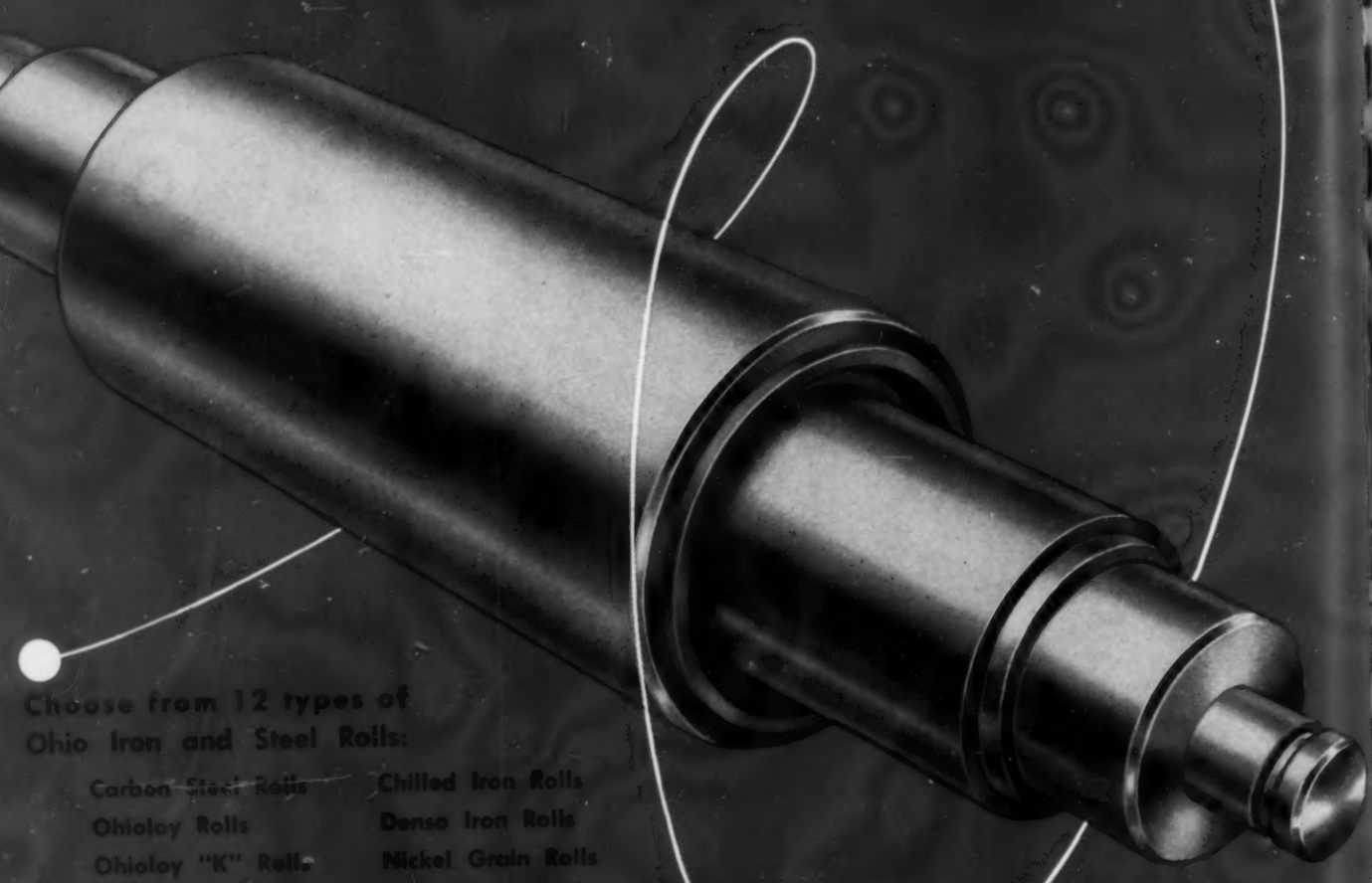
Ohio Rolls

shaping metal for all industry



Choose from 12 types of
Ohio Iron and Steel Rolls:

Carbon Steel Rolls
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THE OHIO STEEL FOUNDRY CO.

LIMA, OHIO Plants at Lima and Springfield, Ohio

ORI

Industry News...

MERGER OF SQUARE D AND EC&M ANNOUNCED

▲ The merger of Square D Co. and Electric Controller and Manufacturing Co. was announced January 5.

Square D, as the surviving company, will operate Electric Controller as a separate division, and becomes one of the nation's largest manufacturers of electrical distribution and control equipment.

Concurrent with the merger, F. W. Magin has become chairman of Square D's board of directors and A. G. Patterson has been named president. Mr. Magin has been chief operating officer of Square D since 1933 and Mr. Patterson has served as president of Electric Controller since 1952. In addition, Dr. John D. Leitch and Alvin C. Dyer, vice presidents and directors of Electric Controller, have been named to similar posts in the merged company.

Electric Controller recently completed a 340,000,000 sq ft plant in Cleveland, where it will remain as a Square D division.

WEIRTON STEEL ORDERS FURNACE FROM LOFTUS

▲ A 600-ton open hearth furnace, which it is said, will be the largest ever built, has been ordered by Weirton Steel Co. The furnace will be designed, engineered and erected by Loftus Engineering Corp. It will be part of National Steel Corp.'s recently announced $200,000,000 expansion program.

National Steel's steelmaking units are considerably bigger than the average in the industry. At its Weirton division, two of its 13 open hearths are 550-ton furnaces, one is 500 tons; five are 450 tons, and five are 225 tons. At the Great Lakes division, 10 of 17 open hearths are 500 tons and seven are 250-ton furnaces, the usual size of most modern open hearths installed in recent years.

Loftus Engineering has received orders for 19 open hearth furnaces so far this year, the units ranging from 50 net ton capacity to the 600 ton capacity furnace ordered by Weirton. The orders have come not only from steel producers in the United States but also from steel mills in Germany and Italy.

EMPIRE STEEL INSTALLS VERSATILE NEW MILLS

New cold rolling equipment recently placed in operation by Empire Steel Co., Mansfield, Ohio, includes this four-stand four-high tandem mill and a two-high temper mill, with complete entry and delivery equipment. Both mills and coil handling equipment were designed and built by E. W. Bliss Co.'s Rolling Mill Division. The tandem mill is a 19 in. and 51 in. by 52 in. with a rated delivery speed from the last stand of 1866 fpm and can roll wide strip. The entry and delivery equipment on both mills can handle coils weighing as much as 34,000 lb. Speed and capacity of the temper mill are closely rated to those of the tandem to enable it to handle the output from the latter, if necessary.

AWARDS PUMPHOUSE CONTRACT TO DRAVO

▲ A contract to expand the water pumping and supply system at the central pumphouse of Jones & Laughlin Steel Corp.'s Aliquippa Works has been awarded to Dravo Corp. The expanded facility is necessary for the operation of a new hot strip mill now under construction by the steel company.

Two of seven 15 million gallon per day pumps will be replaced with two 40 million gallon per day De Laval pumps. The new units will increase the station's total water pumping capacity to approximately 155 million gallons daily.

In addition to the pumps Dravo will furnish and install traveling water screens, a 60-in. water header, all station piping, and a 42-in. pipeline necessary to serve the new hot strip mill. The pumps will be driven by 1750 hp electric motors, also to be installed as a part of the contract.

ANNOUNCES OPENING OF ENGINEERING OFFICE

▲ Opening of an engineering office in Canfield, Ohio has been announced by The Morgan Engineering Co.

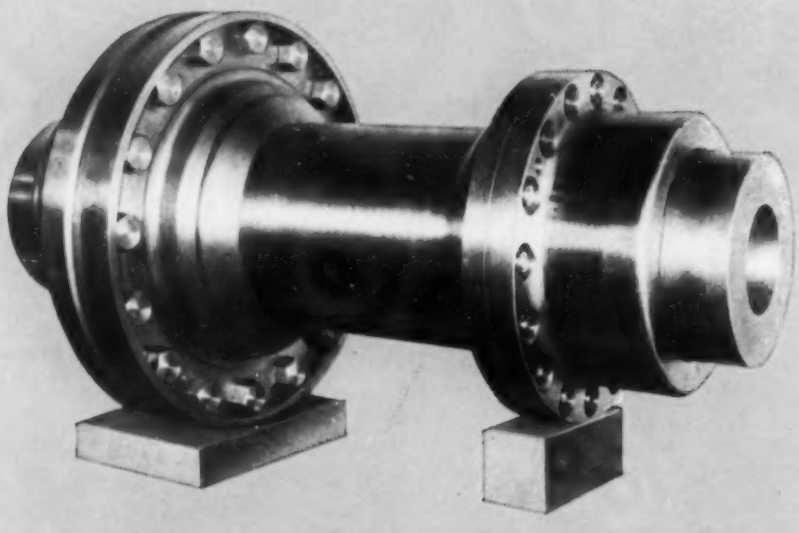
The Canfield office will concentrate on detail work while engineering design and layout work will continue to be done at the main plant in Alliance.

TITANIUM METALS CORP. ORDERS SENDZIMIR MILL

▲ First step in the development of a specialized fabricating facility devoted exclusively to the rolling and forging of titanium was marked by the

1800 lbs.

...is the weight of this SPECIAL forged steel insulated spacer WALDRON GEAR COUPLING



Despite its size and weight, it is in perfect dynamic balance.

The compressor or driven end is a size 8 gear half with the hub taper bored. The main motor, or drive end, is a size 6 gear half with the hub straight bored. The forged steel spacer is 24" long.

The coupling will connect a 14,000 H.P. synchronous motor to an axial compressor. 18,000 maximum H. P. will be transmitted at 3,600 R. P. M.

This special insulated coupling is only one of many special units which we design and make.

We invite your inquiries regarding couplings to successfully solve your particular problem. No obligation.

JOHN WALDRON CORPORATION
New Brunswick, N. J.
Since 1827

Sales Representatives In Principal Cities

Titanium Metals Corp. of America with the placing of an order for a Sendzimir reversing cluster mill for the cold rolling of continuous bands of titanium sheet in widths up to 49 in. This unit will be designed specifically to cold roll large coils of titanium to the extremely accurate gage tolerances and mirror finish long desired by the airframe industry. The mill will cost in excess of $3,000,000.

The new rolling unit will be engineered by Allegheny Ludlum Steel Corp., one of the co-owners of TMCA, and will be installed in an Allegheny Ludlum Pittsburgh-area mill.

Since its industrial birth some five years ago, metallic titanium has been rolled and forged on equipment designed primarily for stainless steel. Order tonnages have now risen to such volume to justify the engineering of major conversion equipment for titanium adapted to the characteristics of this metal. Only one 49 in. Sendzimir mill is in operation, on stainless steel. The engineering of such a precision unit to titanium is the first industry move toward specialization in mill equipment to convert titanium ingots.

SYRACUSE SALES OFFICE ESTABLISHED BY OKONITE

▲ The Okonite Co. has established a sales office and warehouse in Syracuse, N. Y. to operate in conjunction with D. K. Post & Co., manufacturers' agent, at 216 Burnet St. Walter E. Garrigan who has been Pittsburgh district manager since 1946, has been appointed manager of the Syracuse office.

The new Syracuse office will serve industries, railroads and utilities in the northern N. Y. area and will provide a large warehouse for both Okonite and Hazard products.

IRVIN WORKS CONTRACT AWARDED TO SURFACE

▲ The prime contract for a new continuous normalizing line for processing vitreous enameling stock at U. S. Steel Corp.'s Irvin Works has been awarded to Surface Combustion Corp.

The new line will be used to normalize low carbon steel stock at the rate of approximately 15 tons per hour to maximum temperatures of

Bearings, Inc. has The Bearing Accessories

to help make certain the bearings you use give longest service life with less maintenance. The accessories shown here, and many other aids, are now available from any of our Stock Carrying Branches.

WALDES TRUARC RETAINING RINGS

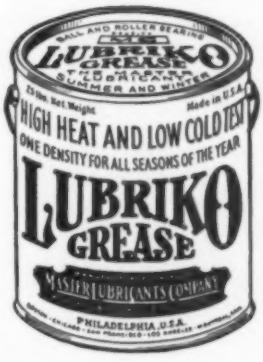
A patented design for constant circularity and grip makes these rings ideal for use in fast rotating axle and shaft assemblies. Truarc rings can be used and reused indefinitely. Constant assembly and disassembly will not affect their tight pressure fit when installed in a groove.

VICTOPRENE OIL SEALS

Assure clean sealing of rotating, oscillating, or reciprocating shafts of all sizes. The oil seal element is highly resistant to oil, grease, heat and age. Designed to compensate for shaft eccentricity and housing misalignment.

LUBRIKO GREASES

Holds consistency even under severe operating conditions with extremely high melting point and very low cold tests. Lubriko is non-gumming, free of moisture and does not separate or cake.

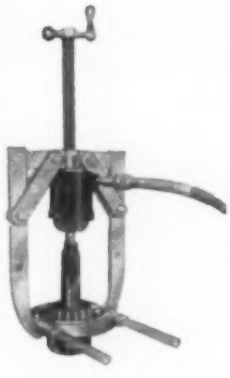


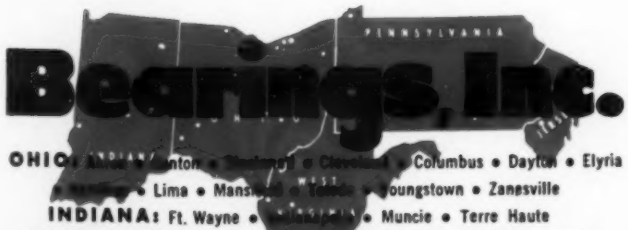
BEARING LOCKNUTS AND LOCKWASHERS

Complete stocks of all sizes of Locknuts and Lockwashers for holding bearings in permanent, correct position. All are manufactured to SAE standards to insure squareness of the threads to the face of the nut. High quality, heat treated steel, finished smooth and free from burrs.

OTC BEARING REMOVAL TOOLS

The most complete and versatile set of tools designed for the removal of bearings, gears, wheels, pulleys, sheaves, bushings, shafts and other close-fitting parts. Hydraulic power takes the work out of pulling jobs and eliminates torque and friction.





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Gentlemen:

I would like to receive full information on the bearings and bearing accessories you distribute.

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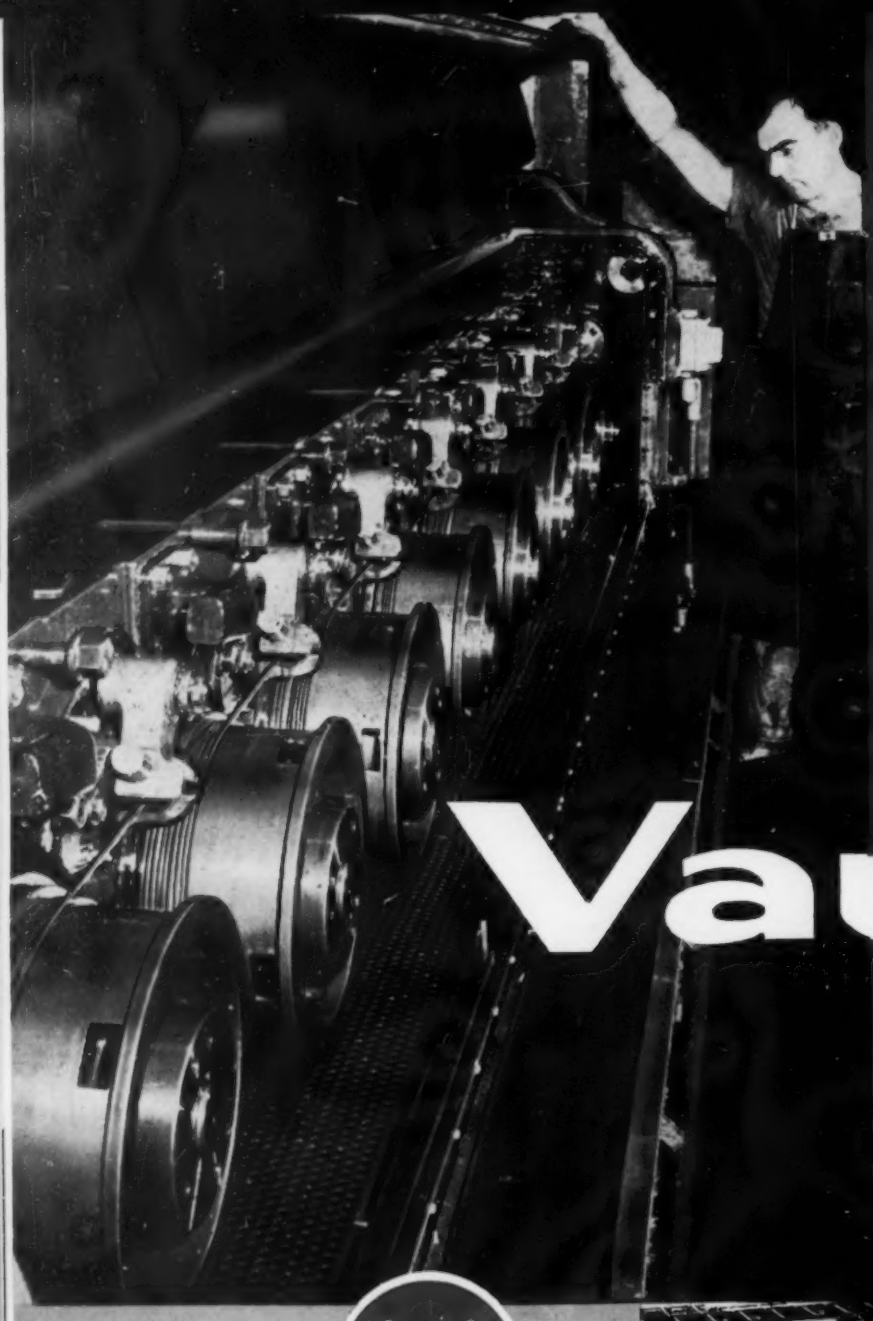

HEAVY-DUTY AND HIGH SPEED

In producing

NON-FERROUS WIRE

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TANDEM MACHINES

Vaughn Tandem Machines have power, speed and stamina to handle with ease your heaviest products in non-ferrous metals. Vaughn experience in design and manufacture is your guarantee of continuous operating satisfaction and long service life. Let us discuss your requirements!

"Quick on the Draw!"

The VAUGHN MACHINERY COMPANY

CUYAHOGA FALLS, OHIO, U. S. A.

COMPLETE COLD DRAWING EQUIPMENT—Continuous or Single Hole . . . for the Largest Bars and Tubes . . . for the Smallest Wire . . . Ferrous, Non-Ferrous Materials or their Alloys.

1850 F. This new facility is to be in operation in the fourth quarter of 1956.

The job comprises strip handling equipment, a horizontal looping furnace, pickling, washing and drying equipment. Surface combustion has placed a sub-contract for the strip handling equipment with the E. W. Bliss Co.

CHANDEYSSON APPOINTS ROSS AS DISTRIBUTOR

▲ Appointment of F. H. Ross & Co. as its distributor in seven Southeastern states has been announced by the Chandeysson Electric Co. Ross will handle the complete Chandeysson line of low-voltage motor generators.

NATIONAL STEEL ORDERS TWO SINTERING PLANTS

▲ Contracts for the construction of two sintering plants, each to be equipped with a sinter machine exceeding the size of any single iron ore sintering unit used in the world today, have been awarded to Koppers Co., Inc., by National Steel Corp. The plants will be erected for Weirton Steel Co. at Weirton, W. Va., and for Great Lakes Steel Corp., at Zug Island, Mich.

In addition, extensive raw ore and sinter handling systems will be built at each of the steel producing plants.

Facilities for Great Lakes Steel will include a sinter machine with a 12 ft wide ore bed and an effective length of 199 ft six in. This huge unit will be capable of producing more than 7000 net tons of sinter per day. The material handling system will be constructed between three ore storage yards and the sintering plants and will include facilities for ore screening and crushing, and a storage system. Approximately 70 conveyors will be used.

The Weirton sintering plant will be equipped with a sinter machine 12 ft wide with an effective length of 168 ft which is expected to produce approximately 6000 net tons of sinter per day. It will be the second sinter machine at the Weirton plant. Presently beginning operation is an eight ft by 104 ft sinter machine capable of producing approximately 2500 net tons of sinter per day. The

Revolutionary

NEW HOOK DESIGN

...assures maximum safety and strength under the most severe conditions!

Avoid smashed fingers, broken hands and other serious and costly accidents with Taylor Chain's new Alloy Steel Tayco Hooks. Patented I-Beam type design provides a safe gripping channel for the hooker's hand ... increases the strength and life of the hook immeasurably.

Large area above the eye further increases the hook's life. Oversized eye reduces joiner link wear. Drop-forged from Alloy Steel and heat-treated—Tayco Hooks have great resistance to shock, grain-growth and work-hardness at all temperatures. Available separately and as standard equipment on all Taylor Made Alloy Sling Chains.

SEE YOUR DISTRIBUTOR, OR SEND COUPON TODAY!

S. G. Taylor Chain Co., Hammond, Ind.; Pittsburgh, Pa.

TAYLOR MADE
A GREAT NAME IN
Chain SINCE 1873

S. G. Taylor Chain Co.
Dept. H, Hammond, Indiana
Please rush Bulletin No. 90 giving all the facts and specifications on Tayco Hooks.

Name_____

Address_____

City_____ State_____

Look Overhead . . . see "NORTHERN"

NORTHERN YARD CRANES

are built for rugged service

All Northern Overhead Electric Traveling Cranes are designed and built to provide the maximum in dependable operation under the most rugged conditions.

High efficiency and minimum maintenance are assured by close tolerance machining of all mechanical parts with turned and ground shafts, press fits of gears, wheels and bearings. Brakes are chosen to allow for extreme overload conditions. Extra heavy structural sections and rigid construction of girders with end trucks insure lateral stiffness, minimum vertical deflection and safe operation when the crane travels at full speed. Heavy duty type motors with anti-friction bearings are combined with especially selected control equipment to assure fine handling.

In plants where bulk material handling is required, as in the steel plant shown above, Northern cranes are a preferred investment for safety, dependability and efficiency.

Write for Bulletin SE-108

MATERIAL HANDLING EQUIPMENT BY NORTHERN

NORTHERN ENGINEERING WORKS
210 CHENE ST., DETROIT 7, MICH.

ore handling system will be designed and constructed to deliver ore from the existing and expanded ore storage yard to both sinter plants.

ADDITIONAL EXPANSION ANNOUNCED BY AIRCO

▲ A $16,000,000 expansion program for 1956 to meet the rapidly increasing demand for its industrial gases is under way by Air Reduction Sales Co., division of Air Reduction Co., Inc. This expansion plus the new facilities completed since 1951 bring Airco's total investment increase in the gas-producing field over the six-year period to about $50,000,000.

Three new producing plants are scheduled for completion this year: at Chicago, Ill., Alton, Ill., and Calvert City, Ky. Additional producing facilities will also be installed at Butler, Pa., and output will be increased at Riverton, N. J. These plants at Butler, Pa., and Riverton, N. J., are the largest Airco plants for producing liquid and gaseous oxygen, nitrogen, argon, and the rare gases such as neon, krypton, and xenon. A portion of the appropriation will go towards expansion of gas-producing facilities in the southwest.

Included as well in this program are additional distribution facilities throughout the country.

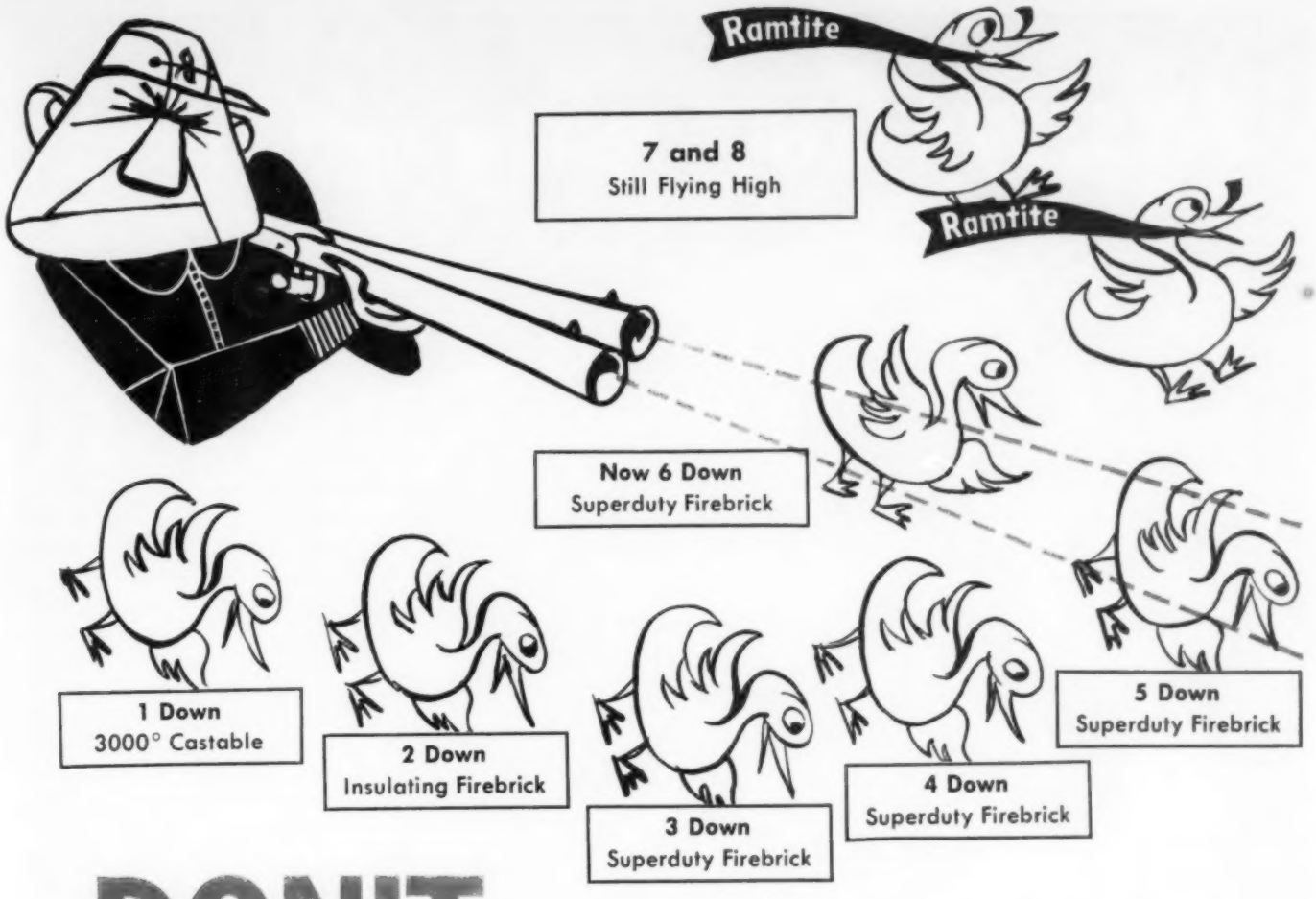
The Chicago installation will produce liquid oxygen, nitrogen, and argon, and will be completed during the last quarter of 1956. At Alton, Ill., the production of the new plant —scheduled for completion by the middle of 1956—will serve the growing industrial area of southern Illinois. The new plant at Calvert City, which is scheduled for completion by the middle of the year, will supply expanding industrial needs in the Calvert City and lower Ohio Valley industrial areas.

Additional facilities at Butler, Pa., scheduled for completion by the last quarter of 1956, will virtually double producing capacity there.

COKE OVEN CONTRACT AWARDED TO WILPUTTE

▲ A contract to build a battery of 78 Wilputte underjet coke ovens and auxiliary coal chemical recovery equipment at Great Lakes Steel Corp. has been awarded to Wilputte coke oven division, Allied Chemical & Dye Corp.

The new ovens will more than



DON'T BE A DEAD DUCK!

6 soaking pit covers, lined with three types of refractories, have lived their lives.

2 Ramtite covers are still flying high.

This is the story of 8 soaking pit covers—installed in new pits—in February, 1952—in an eastern steel mill.

4 covers were—Superduty Firebrick
1 cover was—Insulating Firebrick
1 cover was—3000° F. Castable
2 covers were—Special Super Ramtite No. 25

One after another the insulating firebrick, castable and superduty firebrick failed and were replaced with Ramtite. The two original Ramtite covers are still in service at this date and with no repairs.

CAN YOU AFFORD NOT TO USE RAMTITE? *Ramtite is our business—not our sideline.*

Ramtite soaking pit covers save a lot of material and work.

THE Ramtite CO.
DIV. OF THE S. OBERMAYER CO.

THE RAMTITE CO., Div. of The S. Obermayer Co.
1813 South Rockwell St., Chicago 8, Ill.

Please send items checked

- ☐ Bulletin on Castable and Gunning Refractories
- ☐ Steel Plant Bulletin

Company Name_____

Attn. Mr._____ Title_____

Address_____

City_____ Zone____ State_____

This is another in a series of advertisements depicting ways Ramtite Refractories serve the steel industry

WESTERN GEAR rolling mill drives ...rugged as Gibraltar!

Western Gear 2500 HP Model S-87-MS speed reducer 5.7:1 ratio utilizing double helical staggered tooth gears.

Above, Western Gear designed double 2-high pinion stand, and at right, single 3-high pinion stand manufactured for prominent mill equipment manufacturer for installation in new Italian steel mill.

Western Gear pinion stands, gear drives and other machinery for application in steel rolling mills are backed by experience accumulated since 1888 in the design and construction of mechanical power transmission equipment of every description. It's your guarantee of ruggedness and trouble-free production day in and day out. Anti-friction bearings provide for rock-steady, vibration-free operation so essential to maintain high standards of accuracy and finish. And this same precision helps prolong the life of related machinery, too! Removable end plates on Western Gear pinion stands enable lifting entire gear train for easy inspection without removing housing from bed plate mounting.
To maintain top quality output with a minimum of downtime and overhead, insist on Western Gear drives for rolling mill application.

"The difference is reliability" ★ *Since 1888* 5570

For recommendations on the installation of new equipment or the replacement of obsolete or worn units, write today. Our engineers will be glad to offer their help and experience. Address General Offices, Western Gear, P.O. Box 182, Lynwood, California.

WESTERN GEAR Corporation
ENGINEERS AND MANUFACTURERS

PLANTS AT LYNWOOD, PASADENA, BELMONT, SAN FRANCISCO (CALIF.) SEATTLE AND HOUSTON—REPRESENTATIVES IN PRINCIPAL CITIES

double the capacity of this modern coke plant which was completed by Wilputte in 1954. When the new ovens are in operation 3800 tons of coal will be processed per day, producing 2800 tons of coke.

TITANIUM FIRM ORDERS WESTINGHOUSE FURNACE

▲ The Mallory-Sharon Titanium Corp. has ordered a vacuum annealing and degassing furnace from the Westinghouse Electric Corp.

The car-type furnace will be used for processing titanium ingots and sheets and has a charge space of 4 x 4 x 12 ft. It is said to be the largest vacuum furnace of its type to be built.

Representing a departure from conventional vacuum furnace designs, the Westinghouse Kold-Retort furnace utilizes a water cooled vacuum retort with electric heating elements located inside the vacuum chamber itself. In a vacuum furnace, most of the heat transfer is by radiation, practically none by convection. The new design, therefore, places the heating elements within the retort, and uses radiation shields for thermal insulation, eliminating the necessity for refractory brick linings.

The new furnace will have a rating of 450 kw in six control zones with a maximum operating temperature of 1600 F. The charge chamber can be evacuated to one millionth of an atmosphere.

Meetings

▲ The National Society of Professional Engineers will hold its annual spring meeting February 17-18, at the Mayflower Hotel in Washington, D. C.

▲ The annual conference sponsored by the Pittsburgh Section Instrument Society of America will be staged March 5 and 6, 1956, at Hotel Webster Hall, Pittsburgh, Pa.

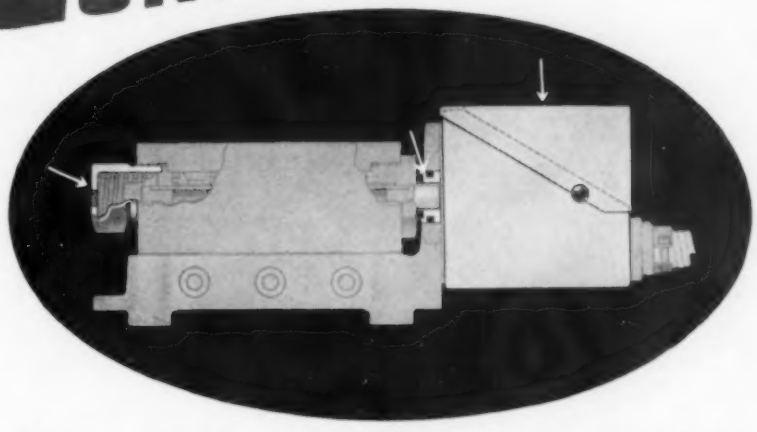
Papers will include: "Cascade Furnace Temperature Control System," "Automatic Load Control," "Gravimetric Blending and Control in Sinter Plant Operation," "Instrumentation and Control of Oxygen Steel Making Vessels," "Electronic vs Pneumatic Control Systems," "Combustion and Control on 80 in. Re-Heat Furnaces," "Telemetering for the Steel Industry," and "Combustion Control of New Surface Furnaces."

SELECT

Quick-As-Wink®

AIR AND HYDRAULIC

CONTROL VALVES



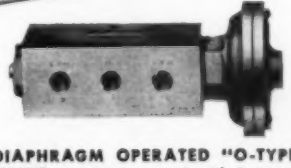
New Dust-Tight Construction

for SOLENOID VALVES

protects all operating parts from Dust and Grit

● Now you can get even greater value in Quick-As-Wink Solenoid Valves — *at no increase in price.* They've been dust proofed. A sintered bronze filter in the breather hole permits air to pass through in either direction, but prevents the entrance of dirt. A sleeve with two "O" rings assures dust-free operation where the solenoid armature contacts the valve plunger. The overlapping cover for the solenoid fits tightly but can be removed easily. It protects the solenoid even from the dust and grit blown around during "cleaning up" operations; provides ample space in which to connect the control wiring to the solenoid leads; and permits the splice to be tucked away inside the cover, not pulled back into the piping. Write for full details — *today!*

Ask us also about . . .



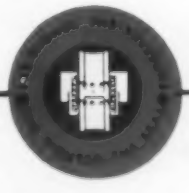
DIAPHRAGM OPERATED "O-TYPE" VALVE, can be actuated with instrument air as low as 12 to 15 psi.

LEVER OPERATED HYDRAULIC VALVE suited for water or hydraulic oils up to 5000 psi. 2-way, 3-way and 4-way actions.

Quick-As-Wink®

AIR AND HYDRAULIC

Control Valves



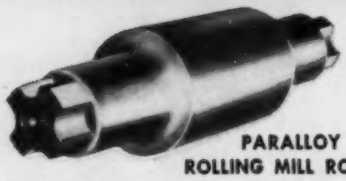
Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

Mfd. by C. B. HUNT & SON, INC., 1926 East Pershing St., Salem, Ohio

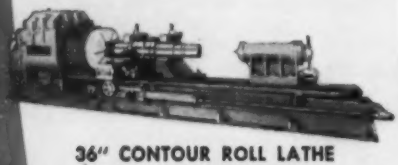
"YOUNGSTOWN" EXPERIENCE PAYS OFF IN BETTER RESULTS FOR YOU

Steel Mill Equipment - Heavy Machines - Complete Lines

SCRUBBER & CLEANING LINE



PARALLOY ROLLING MILL ROLLS
MERCHANT—ROD—BAR—SKELP

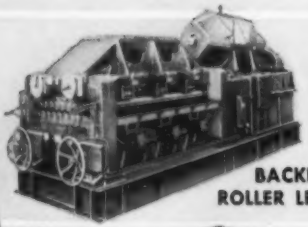


36" CONTOUR ROLL LATHE

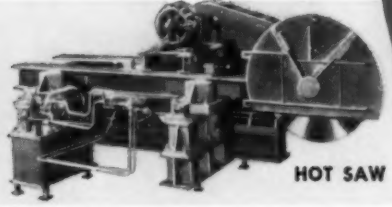
TAKE UP REELS

SLAB PUSHER

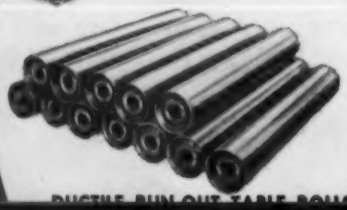
90" x 240" x ¼" STRETCHER LEVELER



BACKED UP ROLLER LEVELER



HOT SAW



DUCTILE RUN-OUT TABLE ROLLS

"Youngstown" Machinery serves major steel mills from coast to coast

"Youngstown" is well-known for its 70 years of experience in the designing, engineering and building of heavy, steel mill machinery. Pictures at left show a few examples . . . Complete lines—major units and auxiliaries. Additional "YF&M" products include ductile iron gears, rolls and castings up to 100,000 pounds.

"Youngstown" also builds extrusion presses and equipment for the "light metals" industry.

Modern Pickling Line cuts costs for western mill

Better pickling with less acid consumption . . . "Youngstown's" latest high speed continuous strip pickling line utilizes a new pull-thru type TRIPLE SCALE BREAKER that eliminates the need for a pinch roll stand.

Complete Scrubber Line built for midwest plant

This typical sheet scrubber line provides the ideal solution to the cleaning problem involving enamel sheet stock, dry or oiled stock, sheets for tin plating and special service sheets.

36" Contour Roll Lathe wins laurels for new improvements

Completely hydraulic tracer control insures smoother, more accurate finish. Featured improvements provide better turning, either on necks or centers. Built to suit specific needs.

Slitting Line speeds production for brass manufacturer

This complete 25" slitting line for brass and copper is giving "right-for-the-job" service. "Youngstown" has the correct answer for any slitting problem, whether it is .002" brass, copper, aluminum, or ⅜" steel plate.

Ductile Run-out Table Rolls excel in hot strip mill

Ductile cast iron rolls are reducing maintenance in leading mills. Especially good under the sprays. Resist heat check and breakage. Ductile iron is the ideal maintenance material for aprons, roller boxes, looper tables and looper rolls.

Consult us about your problems.
Let us quote on your requirements.

The Youngstown Foundry & Machine Co.

SERVING INDUSTRY SINCE 1885

Youngstown, Ohio

SEVENTY-SIX 10-hp d-c approach table motors for McLouth reversing roughing mill.

With the help of G-E system-engineered electrical equipment . . .

McLouth Steel improves hot strip production through increased flexibility and ease of maintenance

The new 60-inch hot strip mill at McLouth Steel Corporation's expanded Trenton, Michigan, plant utilizes individual d-c motors for each roll of roughing mill front and rear tables, as well as roughing and finishing mill approach tables, and pumpless rectifiers in unit substation arrangement to supply power to individual finishing stand d-c motors. These unique applications result in greatly increased flexibility and ease of maintenance.

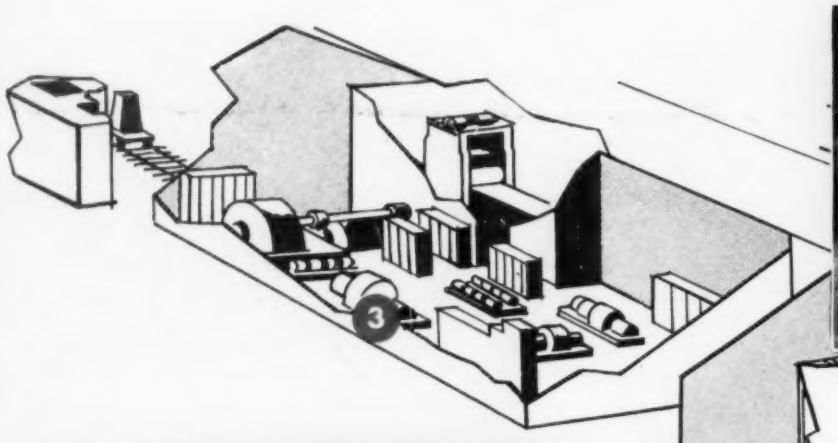
In addition McLouth engineers predict savings of $60,000 per year in lubrication costs alone by switching to individual roll drive d-c motors. This application of individual d-c motors eliminates the need for reduction and bevel gears and line shaft and therefore minimizes maintenance and periods of unscheduled downtime. 659-108

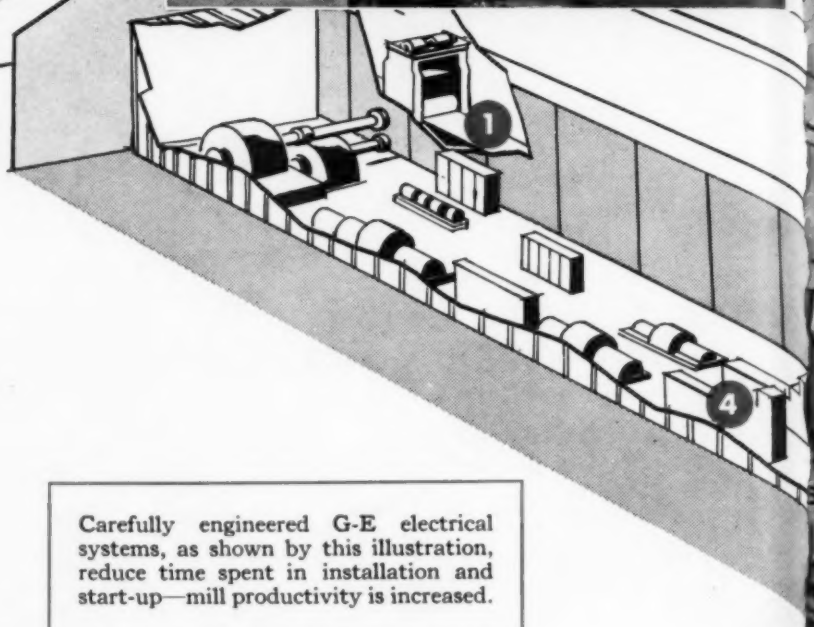
SEE ELECTRICAL SYSTEM LAYOUT ➧

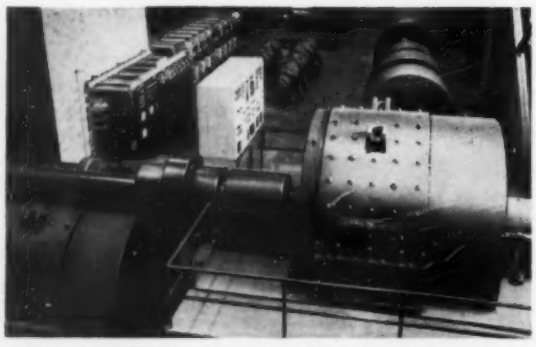
GENERAL ELECTRIC

How General Electric System Engineering He

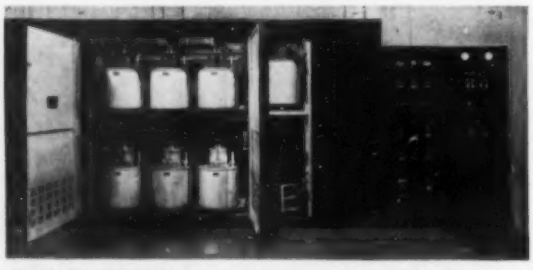
1 146 INDIVIDUAL ROLL MOTORS driving tables result in flexibility of maintenance, decreased operating costs. Engineered design integrates all table sections.







3 MAIN DRIVE for the blooming and slabbing mill is a 6000-hp d-c twin motor backed up by auxiliary m-g sets, d-c switchgear and duplex switchboard.

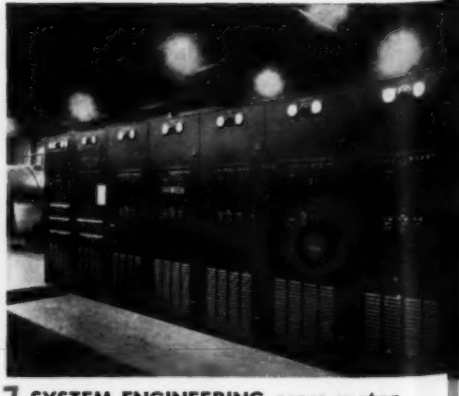


4 THIS SECTION of 4000-kw stand 3 rectifier features new ignitron stainless steel tanks and dual ignitors for dependable service—low maintenance.

Carefully engineered G-E electrical systems, as shown by this illustration, reduce time spent in installation and start-up—mill productivity is increased.

5 ECONOMY OF INSTALLATION for the hot strip mill is achieved by unit substation construction and close location of the rectifier equipment with respect to the stand motor drives.

6 EACH STAND'S regulating autotransformer allows operation over wide speed range by individual stand voltage control.



7 SYSTEM ENGINEERING eases motor room operation by centralizing master control functions for mill stands in this duplex control switchboard.

Helped McLouth Increase Productivity

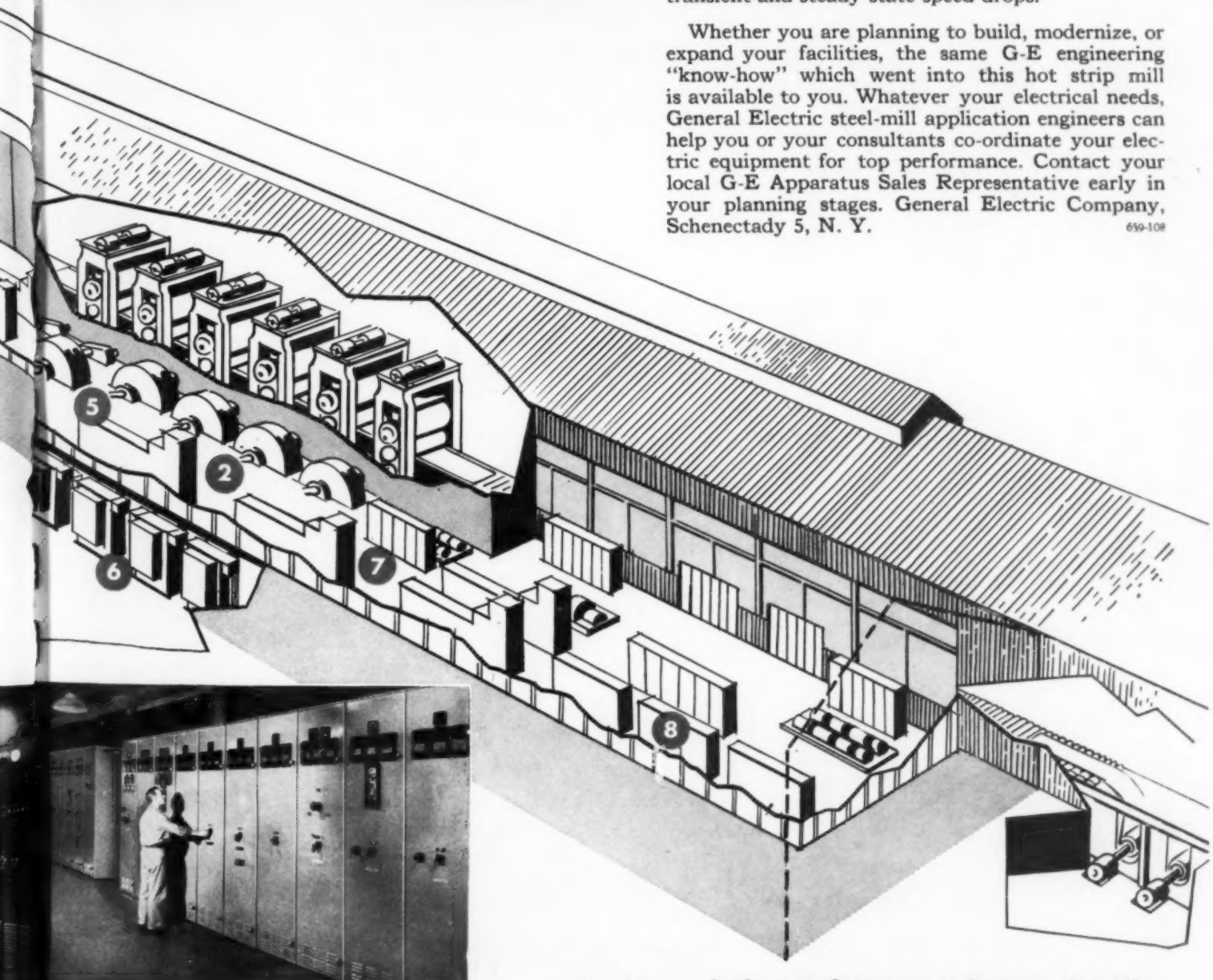
2 **A TOTAL OF 28,500-HP** supplies the "muscle" for the 60-inch 6-stand hot strip finishing mill. Motor room stand 1 to 5 motors are rated 5,000-hp. Stand 6 motor (on right) furnishes 3500-hp.

EXCELLENT EXAMPLE OF STEEL MILL PROGRESS

McLouth's new hot strip mill is an excellent example of the progress made in the application of electrical equipment to semi-continuous hot strip mills. This new plant, in full production 15 months from date of order, will produce up to one million tons of strip annually.

G-E designed individual-rectifier control gives the mill greater flexibility and simplicity of operation, plus a higher percentage of "on-gage" strip. G-E d-c drive motors are specially designed to withstand frequently repeated heavy loads with minimum transient and steady state speed drops.

Whether you are planning to build, modernize, or expand your facilities, the same G-E engineering "know-how" which went into this hot strip mill is available to you. Whatever your electrical needs, General Electric steel-mill application engineers can help you or your consultants co-ordinate your electric equipment for top performance. Contact your local G-E Apparatus Sales Representative early in your planning stages. General Electric Company, Schenectady 5, N. Y. 659-108



8 **ALL INCOMING POWER** flows through this a-c metal-clad switchgear. Reliable magne-blast air circuit breakers provide service entrance and feeder protection.

Engineered Electrical Systems for Steel Mills

GENERAL ELECTRIC

LADLE BY POLLOCK

More than half of the Nation's open hearth ladles built by Pollock.

This 268-ton open hearth ladle at the Portsmouth Division of Detroit Steel Corporation was designed and fabricated by The William B. Pollock Company. Pollock has more experience in engineering and building iron and steel plant equipment than any other company—92 years of it. Pollock engineers are at your service. Pollock facilities will handle everything from a 10-ton ladle to a complete blast furnace.

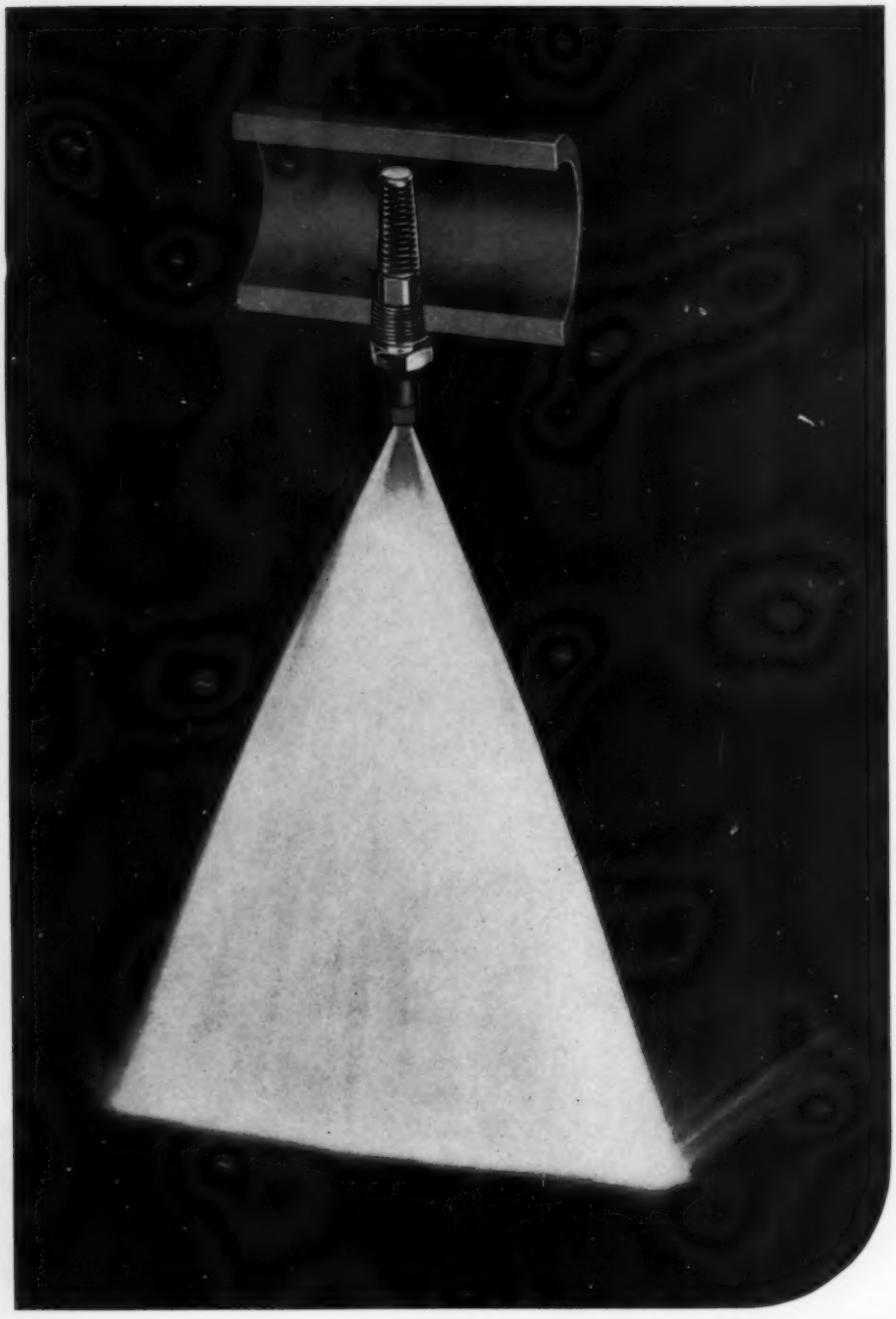
THE WILLIAM B. POLLOCK COMPANY

Since 1863

YOUNGSTOWN, OHIO

ENGINEERS • FABRICATORS • ERECTORS • STEEL PLATE CONSTRUCTION

BLAST FURNACES • HOT METAL CARS AND LADLES • CINDER AND SLAG CARS • INGOT MOULD CARS • CHARGING BOX CARS • WELDED OPEN HEARTH LADLES



SPRAYING SYSTEMS

descaling NOZZLES

with open, elliptical non-clogging orifice

for performance *in full measure*

you can SEE the difference

When you consider performance in all its aspects, here are spray nozzles for descaling that give outstanding full measure. Descaling itself is carried out with an efficiency as high as or higher than any other nozzle made. But equally important, Spraying Systems nozzles give you low first cost . . . **plus non-clogging design** that **reduces** the cost of down-time and maintenance to a minimum.

The thin, concentrated, uniform spray strikes with greatest possible impact for any volume and pressure . . . descales without excessive sheet cooling.

Clogging is practically eliminated by *elliptical*-shaped orifice . . . foreign matter goes right through.

CHOICE OF SIZES . . . offered in 16 different capacities . . . for every known descaling use.

Designed and manufactured by America's leading producers of industrial spray nozzles. For complete information write for Data Sheet 6120.

SPRAYING SYSTEMS COMPANY 3262 Randolph Street • Bellwood • Illinois

Spray Nozzles also supplied for such applications as Run-Out Table Cooling . . . Roll Cooling . . . Cooling Ingot Molds and many other uses. For complete information write for Catalog No. 24.

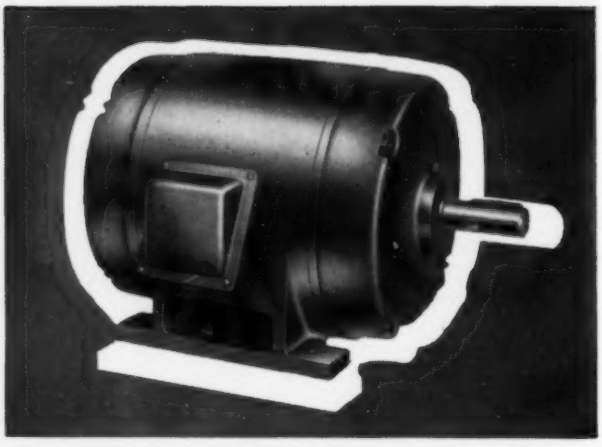
Wagner®
ELECTRIC MOTORS
... the choice of leaders in industry

You get better performance with these Wagner DP Motors

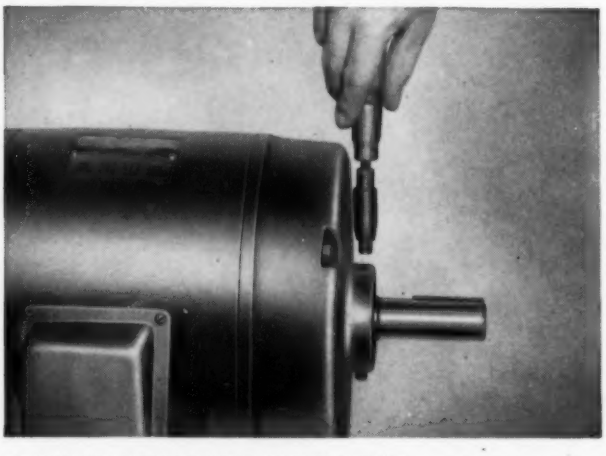
Wagner DP motors are *doubly protected* by (1) rugged, corrosion-resistant cast iron frames, smoothly rounded so that no moisture can collect on them. Motor feet are cast as an integral part of the frame for maximum strength and rigidity. (2) Enclosures on the DP motor are completely drip-proof—virtually splashproof. Air intakes are located at the bottom of the endplates and air outlets are located at the base of the frame—one on each side.

Although engineered to meet the re-rated NEMA specifications which call for more power in smaller frames, the same high quality and long life performance that have made Wagner Motors "the choice of leaders in industry" for many years has of course been retained.

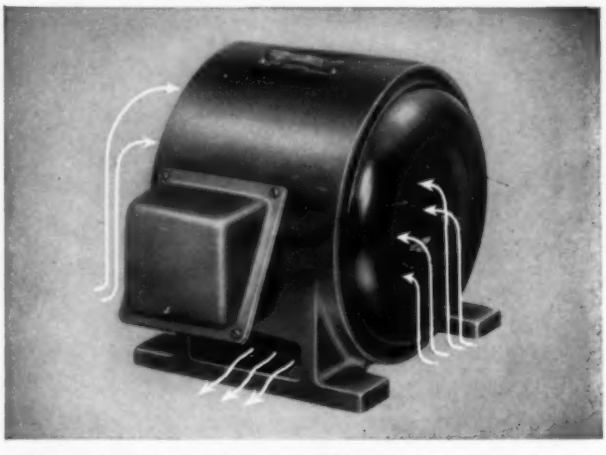
Full information and principal dimensions are given in Bulletin MU-202. Write for your copy today.



MORE POWER IN SMALLER FRAMES The Wagner DP Motor packs more power in a smaller frame and this smaller size means ease of handling and stocking ... less space required for installation.



CAN BE RE-GREASED FOR LONGER LIFE This motor will operate for years without regreasing ... bearings are completely enclosed ... however, provisions have been made for adding lubricant and for the removal of old grease in cases where re-greasing is necessary.



COOL RUNNING Specially designed baffles direct cooling air from the blowers through the motor and provide protection for the stator windings. Blowers are an integral part of rotor ... and move large volumes of air without noise or vibration.

Wagner Electric Corporation
6483 **Plymouth Ave., St. Louis 14, Mo., U.S.A.**

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

M56-4

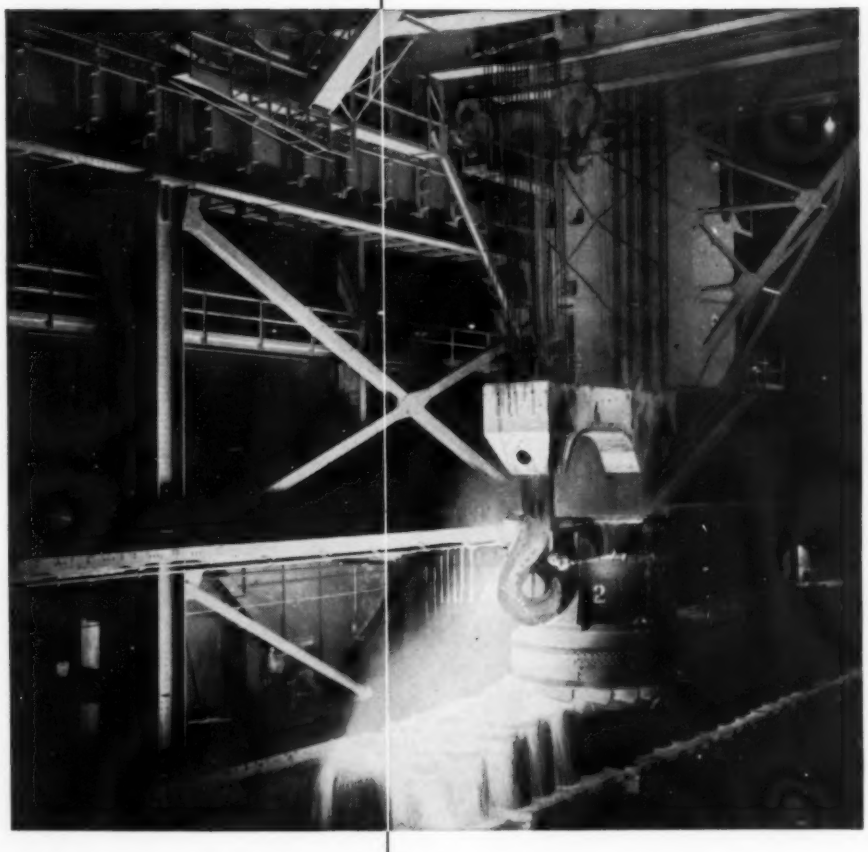
ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS–AIR AND HYDRAULIC

Morgan cranes stop "on a dime"

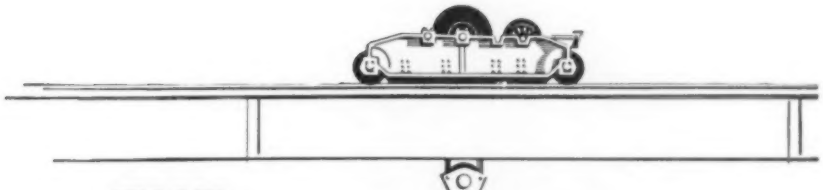
● BRAKING a Morgan crane under full load is as easy as stopping the family car.

Morgan hydraulic crane brakes provide maximum safety and pin-point accuracy in spotting heavy loads . . . another vital link in the chain of features that makes Morgan cranes best in the business.

Performance records prove that advanced design and heavy-duty construction of Morgan cranes make them less costly to operate and maintain. Let our representative show you how to save the most by buying the best . . . Morgan!

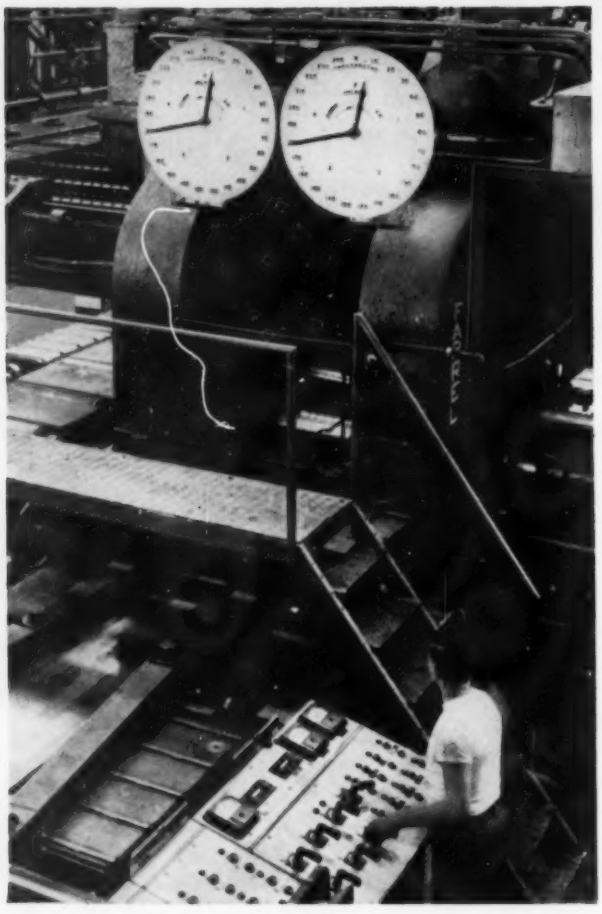


Positive action encourages operators to use the hydraulic brake rather than plug the motor.



The Morgan Engineering Company, founded in 1868, manufactures overhead electric traveling cranes, gantry cranes, charging machines, plate mills, blooming mills, structural mills, shears, saws, and auxiliary equipment.

THE
MORGAN
ENGINEERING CO. *Alliance, Ohio*



This 30" x 36" two-high, cold brass, breakdown mill is the largest ever designed for the nonferrous metals industry. Handles 3000 lb. bars, 25½" wide, 3" thick, and 120" long. Seven passes reduce these bars to flat metal .540" thick and 62 feet long.

NEED A ROLLING MILL FOR *SPECIALIZED PRODUCTION?*

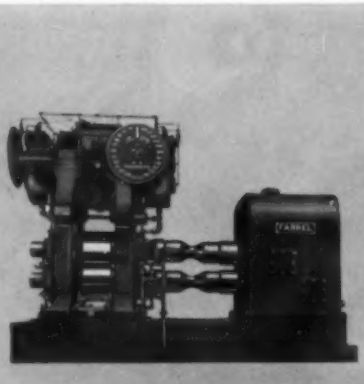
Each mill on this page is an efficient, economical solution to a specific production problem. Each benefits from nearly 100 years of manufacturing experience and a progression of job-tested design improvements.

A Farrel® mill built to your exact needs could be equally beneficial. Just give us your requirements and one of our engineers will be glad to discuss your problems with you.

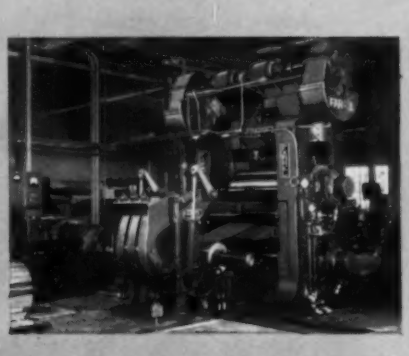
Farrel mills come in a wide range of types and sizes for rolling nonferrous rods, strips or sheets, metal foils and cold strip steel.

Send for 36-page bulletin, which describes in detail Farrel's broad line of rolling mills, gear drives, pinion stands, and special handling equipment.

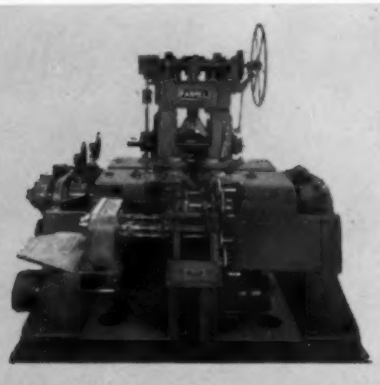
FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONNECTICUT
Plants: Ansonia and Derby, Conn., Buffalo and Rochester, N. Y.
Sales Offices: Ansonia, Buffalo, New York, Akron, Chicago, Fayetteville (N.C.), Los Angeles, Houston



10" x 10" mill specially designed for close gauge control in continuous, high-speed, cold-rolling of high-carbon strip steel. High-powered screwdown permits gauge adjustment under full load.



Designed specifically for increasing aluminum foil production, this mill has 9" x 46" work rolls and 21" back-up rolls. Speed of operation can be varied to meet production requirements.



22" mill for cold-rolling commutator bars. Straightener and roll edger designed into assembly so bars of commonly used size can be straightened, edged and cold-rolled in one continuous operation under precise dimensional control.

FARREL® ROLLING MILL MACHINERY

Rolls • Rolling Mills • Rod Mill Tables and Manipulating Equipment • Universal Mill Spindles • Rod Coilers • Gears • Mill Pinions • Pinion Stands • Gear Drives of Any Capacity • Flexible Couplings • Roll Grinding Machines • Roll Calipers

Farrel-Birmingham®

FB-1025

Personnel News...

Bernard L. Jones was named to the newly-created position of chief engineer for Crucible Steel Co. of America. At the same time, **Tore Wallin** was named assistant chief engineer. Mr. Jones began his career with the U. S. Steel Corp. in Chicago. Since then, he has been engaged in steel plant planning for major developments in Russia, Israel, Yugoslavia, Egypt, and Central European countries as well as in the United States. Prior to joining Crucible in 1950, he was employed by Inland Steel Co. at East Chicago, Ind., for ten years. Mr. Wallin has been with Crucible since 1923, when he joined the company's engineering staff at Midland, Pa. He was named chief engineer at the company's Park Works, Pittsburgh, in 1930 and served there until his appointment as planning and development engineer at Crucible headquarters in 1953.

John N. Miller has been appointed assistant to the president of Jessop Steel Co., with responsibility for production planning. Mr. Miller joins Jessop after 25 years with Universal-Cyclops Steel Corp., where he was general manager of production.

George Endicott has been promoted to executive vice president of Morgan Construction Co. **Charles S. Mercer** succeeds Mr. Endicott as manager of the Morgoil bearing department. Other promotions include: **Norman A. Wilson,** manager of research department, **Richard W. Young,** assistant chief engineer, **E. Raymond Comtois,** chief draftsman, and **Andrew C. Marsters,** proposal engineer.

P. W. Koenemund has been appointed chief engineer of Wheeling Steel Corp., succeeding **M. D. Ayers,** resigned. Mr. Koenemund was general manager of the Benwood works prior to his appointment. **H. N. Lang,** formerly superintendent of the tube mill department, Benwood works, succeeds Mr. Koenemund as general manager at Benwood.

John S. Hawley, who has been serving as assistant to the vice president in charge of operations, has been appointed manager of the Buffalo plant of the Wickwire Spencer Steel Division, Colorado Fuel and Iron Corp. He succeeds **Alfred E. Giblin** who is retiring. In addition, **Edward Dattisman** was named general superintendent of the Buffalo plant. Mr. Dattisman joins the company after serving in an executive post with the United States Steel Corp., at Trenton, N. J.

Donald C. Duvall was elected vice president–industrial relations, Pittsburgh Steel Co., succeeding **Garrett A. Connors** who has retired. Mr. Connors, a Pittsburgh Steel vice president since 1939, will continue as an industrial relations consultant to the company. Mr. Duvall was formerly Monessen Works manager. **Carl A. Breuer,** formerly assistant to the vice president–operations, was named general manager of operations. **Edward A. Dawson,** formerly division superintendent of rolling mills at Monessen, will replace Mr. Duvall as Monessen Works manager. **Albert Lami** will become assistant works manager at Monessen. He was formerly works metallurgist. **Kenneth Geiselhart,** formerly general foreman of the blooming mill, will become superintendent of the blooming and bar mills at Monessen Works. **C. H. Williams,** formerly superintendent of wire mills at Monessen, will become superintendent of wire and rod mills there. **T. F. Jenion** will become assistant works manager of Allenport. He was previously works metallurgist.

Henry Roemer was appointed to the office of president of Sharon Steel Corp., succeeding **Henry A. Roemer, Jr.,** who has resigned. The former will continue to serve as chairman of the board, chairman of the executive committee, and chief executive officer.

Edwin C. McDonald has been appointed chief combustion engineer of Republic Steel Corp. Prior to this appointment, Mr. McDonald was assistant chief combustion engineer.

Adam J. Hazlett, consultant to the president of Jones & Laughlin Steel Corp., has retired after 45 years service in the industry. Mr. Hazlett was executive vice president, a member of the board of directors, and a member of the executive committee at Jones & Laughlin until he reached the statutory retirement age a year ago. He continued active association with J&L, however, as consultant until his actual retirement December

BERNARD L. JONES

TORE WALLIN

JOHN N. MILLER

GEORGE ENDICOTT

DAVID LYLE

A. E. MURTON

DR. F. H. ALLISON, JR.

RICHARD C. BANNON

31. Mr. Hazlett spent his entire business career in the steel industry. He joined the West Penn Steel Co. in 1910. He went to the Eastern Rolling Mill Co. in 1919 — and was elected president of that firm in 1927. He held that position until he joined J&L in 1938 as manager of sales for strip and sheet products.

David Lyle has been appointed vice president–rolling mill engineering of both Continental Foundry & Machine Division and Lewis Machinery Division, Blaw-Knox Co. **A. E. Murton** has been named vice president –roll sales of both Continental Foundry & Machine Division and Blaw-Knox Rolls Division. **Dr. F. H. Allison, Jr.,** will serve as vice president–roll metallurgical research of Continental Foundry & Machine and Blaw-Knox Rolls divisions. **B. P. Hammond** has been named vice president–eastern casting sales, and **H. A. Forsberg,** vice president–western casting sales, both of Continental Foundry & Machine Division.

Richard C. Bannon, vice president and director of Waterbury Farrel Foundry and Machine Co., has been made vice president in charge of sales. Mr. Bannon has been district manager of the Cleveland sales office since 1941. He was elected to the office of vice president in 1954, and was made a director of the company in 1955.

Hubert C. Smith has been elected vice president in charge of operations of the Eastern Division of the Colorado Fuel and Iron Corp. Mr. Smith was former vice president, quality and research, for the Great Lakes Steel Corp.

Martin C. Falk has been appointed chief research engineer for the Yoder Co. Mr. Falk came from Warren Steel Division of Copperweld Steel Corp. Since 1936, when he came to this country from Germany, he has also been with Westinghouse Electric Corp. and Pittsburgh Plate Glass Co.

Joseph Solari was elected executive vice president of Great Lakes Carbon Corp.

Wilbert A. Walker, formerly vice president–accounting, has been elected comptroller of United States Steel Corp. Mr. Walker succeeds **Robert C. Tyson,** who continues as vice chairman of the finance committee. Mr. Walker also continues as a vice president. **L. C. Simmons** succeeds Mr. Walker as vice president–accounting.

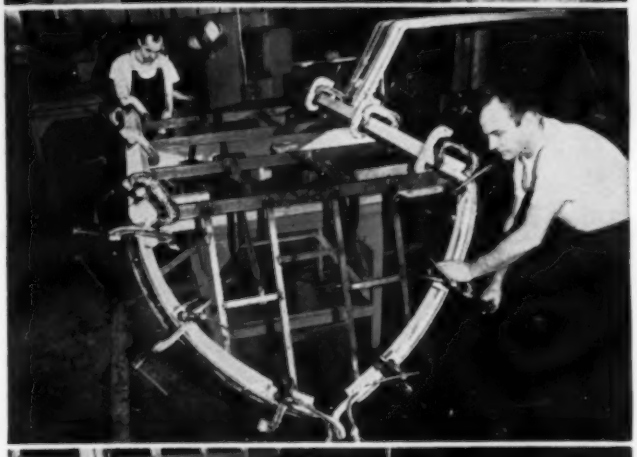
Dr. John D. Leitch has been appointed vice president–engineering and **Alvin C. Dyer,** vice president and general manager of the Electric Controller and Manufacturing Co., a division of Square D Co. Both positions are newly created by the company. Dr. Leitch will have headquarters in the Detroit executive offices and coordinate engineering activity for Square D plants in nine U. S. cities and in Toronto and Mexico City. He formerly was vice president and chief engineer of Electric Controller, prior to its recent merger into the Square D Co. as an operating division. Mr. Dyer will have offices in the new Cleveland plant of Electric Controller. Prior to the merger, he was vice president–sales for the Ohio company.

George A. Jedenoff was named assistant general superintendent, Pittsburg Works, Columbia-Geneva Division, United States Steel Corp., and **R. L. Dowell,** was named assistant to the general superintendent.

Raymond L. Walsh, assistant vice president and chief engineer of Universal Atlas Cement Co. retired December 31 after 30 years of service. He will be retained by the company in a consulting capacity. **Chester D. Rugen** was appointed assistant vice president–engineering and **Robert B. Jordan** was named chief engineer.

Paul C. Meyer has been elected a vice president of the Henry J. Kaiser Co. and will be responsible for all administrative activities of the Kaiser Engineers Division and its subsidiaries.

Edwin H. Burke was named chief engineer, mills and machinery of the Morgan Engineering Co. Other appointments include: **Luther E. Romoser,** chief proposal engineer; **George M. Hoffman,** chief electrical engineer; **Irwin W. Evans,** chief development and welding engineer, and **Percy Stockburger,** acting chief crane engineer. Mr. Burke formerly was associated with United Engineering and Foundry Co. and Crucible



The three photos above were taken recently in our plant during production on an emergency schedule of a set of stator coils for a large turbo generator. Despite the large size of the machine, a complete set of 54 coils (each weighing 130 lbs.) was ready to ship 24 working days after the order was received. While coils were being manufactured, a crew had completed restacking the burnt-out laminations on the stator. Coil installation and testing required only 14 working days and the generator was back at work. Complete details on this job available on request.

Why you can count on National for fast rewinding service:

- a large staff of skilled engineering specialists
- wide experience with all types of large rotating electrical equipment, including that of foreign manufacture
- a wire mill and an extensive stock of raw copper for on-the-spot wire production as it is needed
- a complete department for the fabrication of all necessary insulating materials
- specialized tools and equipment for every operation
- a large crew of skilled workmen for coil production and installation
- highly competent field engineers for on-the-job supervision of coil installation — anywhere in the world.
- a willingness to work around the clock, if necessary, until your out-of-service equipment is back at work

Don't wait until an emergency arises to get acquainted with National facilities and services. Write today for the complete story.

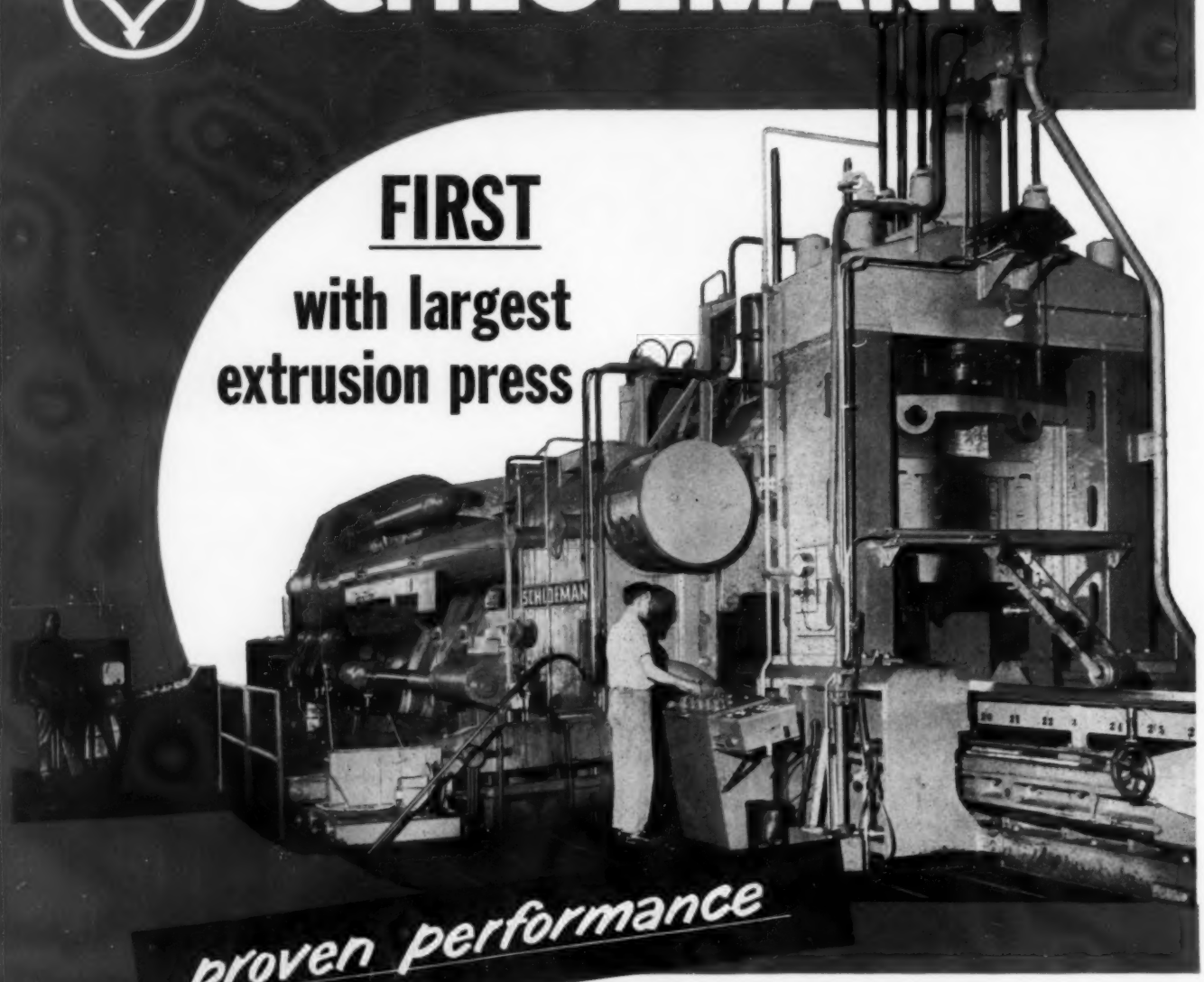
NATIONAL ELECTRIC COIL COMPANY

COLUMBUS 16, OHIO, U. S. A.

ELECTRICAL ENGINEERS: MAKERS OF ELECTRICAL COILS AND INSULATION—
REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES

SCHLOEMANN

FIRST
with largest extrusion press



proven performance

14,000 ton Extrusion Press

This Schloemann Press is now completing two years of successful operation. As a key unit of the U. S. Air Force Heavy Press Program, this Schloemann press produces light metal shapes up to 110 feet in length and up to 2500 pounds in weight. Substantial economies are made possible with this unit as well as greater flexibility of product design.

You are invited to contact our engineers for a dicussion of your extrusion press requirements for any industrial production.

Existing Equipment by **SCHLOEMANN**

Domestic users of equipment built by Schloemann are assured of competent service-engineering, supply of genuine spare, and repair parts. Call a Feller service engineer.

FELLER ENGINEERING COMPANY

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Steel Co. of America. Mr. Hoffman was associated with Trion, Inc., and was assistant chief electrical engineer at the Peter F. Loftus Corp. before joining Morgan. Mr. Evans formerly was a senior scientist at Westinghouse Electric Corp.'s Atomic Power Division and assistant superintendent at the Dow Chemical Co. Mr. Stockburger has been in the engineering division of the Morgan Co. for 43 years, and Mr. Romoser for 39 years.

Alex Glass has been appointed superintendent of the maintenance department at Wheeling Steel Corp.'s Beech Bottom Works. Mr. Glass joined Wheeling Steel in 1950 as supervisor of spare equipment, Steubenville works, and has been in that position until his recent appointment.

Robert E. Peterson has joined the Pittsburgh office of the Clark Controller Co. as a district application engineer. Prior to joining Clark, he was associated with the Monitor Controller Co. for eight years in engineering and sales capacities.

A. Stewart Murray was elected president of the Tyson Bearing Corp., subsidiary of SKF Industries, Inc. Assistant to the president of SKF, and a Tyson director since March, 1955, Mr. Murray replaces **H. I. Lewis,** who resigned as president and as a director, but who will be available to Tyson as a consultant and adviser. Mr. Murray brings to his new post a background of more than 20 years experience in the ball and roller bearing industry. **Edwin R. Broden,** president and a director of SKF, was elected chairman of the board of Tyson and a director. He replaces **Richard H. DeMott,** who announced his resignation as chairman of the board and director of Tyson.

Fred P. Teichart has resigned as technical advisor with Altos Hornos de Mexico to become erecting engineer for Koppers Co., Inc. Mr. Teichart will erect a styrene monomer plant for Cia. Brasileira de Estireno at Cubatao Brazil.

Heinz Helmut Borger, originally affiliated with Mannesmann-Meer AG in M-Gladbach, Germany has recently been transferred to the United States branch in Easton, Pa. While in Germany, Mr. Borger headed the cost control department of Mannesmann-Meer AG. Prior to that he was employed for two and one-half years with DMM (machinery) in London, as a field sales representative of tube rolling mills and in the field of powder metallurgy.

Jeff H. Howell has been appointed superintendent of hot strip finishing at the Warren, Ohio, steel plant of Republic Steel Corp. In another advancement, **A. F. Prust** was named assistant chief metallurgist at the Warren plant. Mr. Howell had been hot mill turn foreman. Mr. Prust was general foreman in the metallurgical department.

Gilbert R. Semans was appointed assistant director of metallurgy and research by Jessop Steel Co. Mr. Semans formerly was a research associate at Universal-Cyclops Steel Corp.

Robert F. Kniffin was appointed assistant industrial engineer of the Cleveland, Ohio, steel plant of Republic Steel Corp. He succeeds **J. Vaughan Byrne** who was transferred to the general office of the company.

William E. Haskell has been appointed assistant general superintendent, United States Steel Corp., South works plant, Chicago, Ill.

John W. Leber has been appointed division industrial engineer–raw materials for Jones and Laughlin Steel Corp. Mr. Leber was formerly mine industrial engineer at J&L's Michigan Ore Division. He replaces **Charles E. Woll,** who has been named assistant works industrial engineer at J&L's Pittsburgh Works Division.

George E. Kopetz has been appointed vice president –production of Blaw-Knox Co.

Dr. C. M. Kruger was appointed general manager of the South African Iron and Steel Industrial Corp., Ltd., and **E. Klein** was named development manager. In addition, **Dr. C. P. Warden** was appointed production operations manager.

Allen H. McElheny has been appointed resident construction engineer at the Cleveland Works of Jones

ROBERT E. PETERSON

A. STEWART MURRAY

F. P. TEICHART

HEINZ HELMUT BORGER

& Laughlin Steel Corp. Mr. McElheny joined J&L in 1946 as construction engineer at the Pittsburgh Works. From 1951 to 1955 he was construction projects superintendent at Pittsburgh.

Myron A. McAlpine was elected superintendent, merchant mills, Indiana Harbor Works, The Youngstown Sheet and Tube Co.

Richard H. Ewert has been appointed to the newly-created position of manager–gearing sales at Foote Bros. Gear and Machine Corp. **Theodore C. Beug**

RICHARD H. EWERT

was appointed advertising manager for both the Industrial and Precision Divisions of Foote Bros. Gear and Machine Corp. Mr. Beug will be responsible for the statistical sales control program as well as all advertising for the company.

THEODORE C. BEUG

William W. Holloway, Jr. and **Clarence Thurnes** have been appointed assistant superintendents–tube department at Wheeling Steel Corp. Prior to his appointment, Mr. Thurnes was technical assistant to the superintendent. Mr. Holloway was formerly a mechanical engineer at the Benwood works of Wheeling Steel. In addition, **John W. Gallagher** has been appointed chief production engineer. Mr. Gallagher joined Wheeling Steel in 1951 as a practice engineer at the Martins Ferry factory. In 1953, he was made a production engineer.

W. G. Frank, formerly executive vice president, has been named president of the American Air Filter Co., and **W. M. Reed** has been elevated from president to the newly created post of chairman of the board.

E. B. Suydam has been appointed president of Linde Air Products Co. Mr. Suydam succeeds **T. D. Cartledge** who continues as a vice president of the corporation. In addition **William M. Haile** was appointed a vice president.

William G. Stewart has been named president and chief executive officer of Universal-Cyclops Steel Corp., succeeding **Edward L. Stockdale,** who becomes chairman of the board, in addition to serving as a consultant. **W. J. Long** was named vice president–sales, and **Walter E. Baker,** vice president–operation.

Henry Bryk has been appointed by Metal & Thermit Corp. as superintendent of its Thermit Metal Department. He will be located at the company's Carteret, N. J., plant.

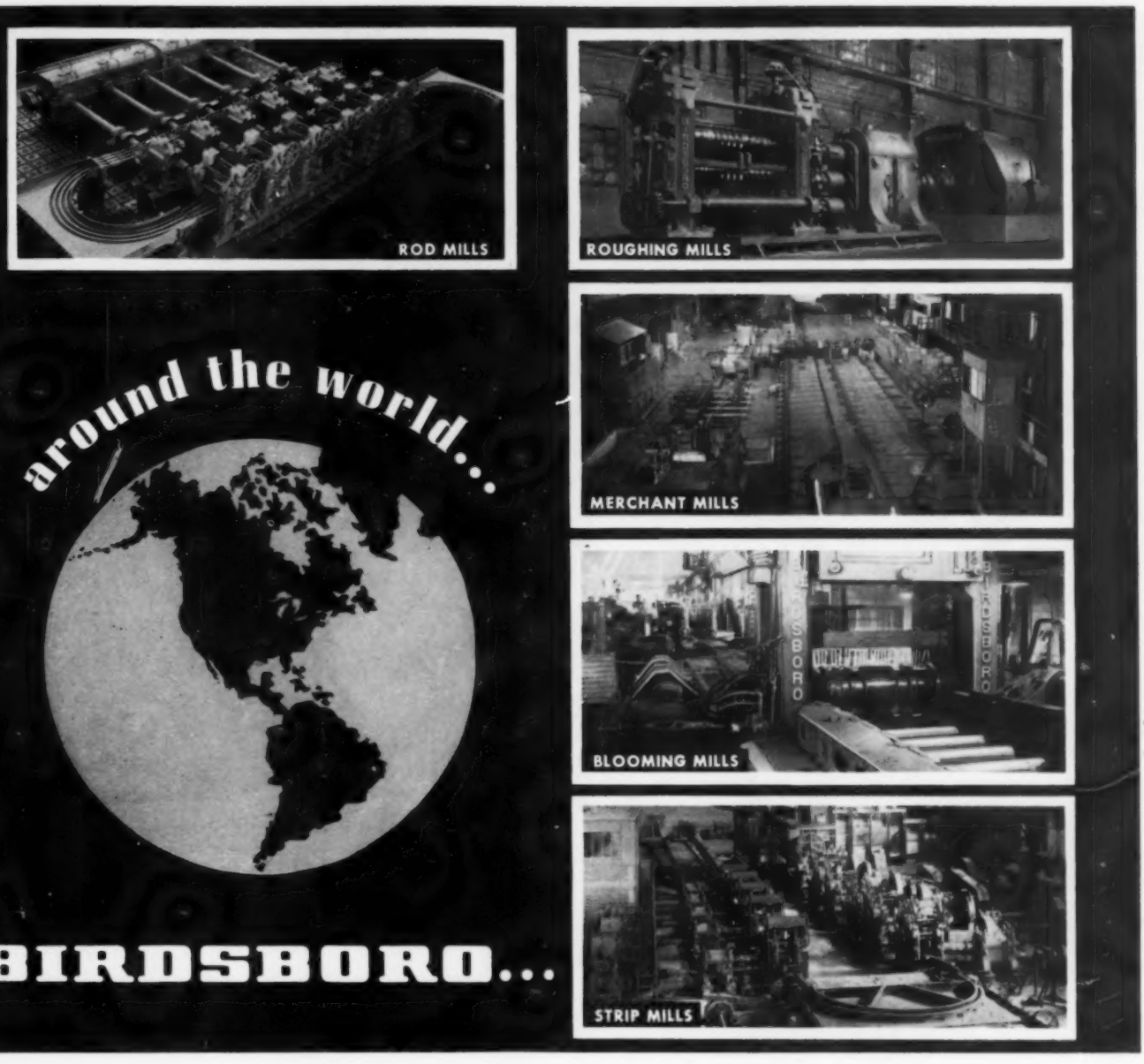
HENRY BRYK

Luke E. Jacobs has been appointed district manager of SKF Industries, Inc., Cincinnati office. In addition, **G. E. Mayhew** has been appointed assistant district manager of the Cleveland office. **William Richardson,** who previously represented the company in both the Cleveland and Cincinnati districts, will operate exclusively in the Cleveland area.

John S. Askey was appointed section engineer, Insulation Section, Elliott Co. This activity includes both development work and design applications. For the last four years, he has served as assistant works manager of the Ridgway Division.

Donald G. Sturges, formerly director of operations of the AEC plutonium plant in the state of Washington, has been appointed manager of the new products branch of the Research and Development Division of the Carborundum Co.

Ralph E. Fritzsche and **George J. Lawson** have been appointed district application engineers by Clark



is known for dependable mill equipment!

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STEEL MILL MACHINERY
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SPECIAL MACHINERY
STEEL CASTINGS
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ROLLS: Steel, Alloy Iron, Alloy Steel

• Whatever you need in mill equipment . . . wherever you need it . . . BIRDSBORO is ready to give you "customized" service, from the manufacture of a single unit to the design, building and installation of complete mills and auxiliary equipment.

MM 43-55-R

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Over 15 years' experience in

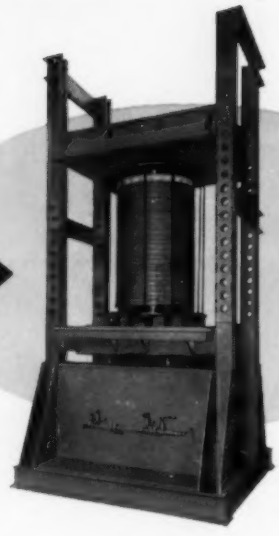
"Putting on the Pressure"

is your proof that your

PENNSYLVANIA

Power TRANSFORMER

will withstand short circuits

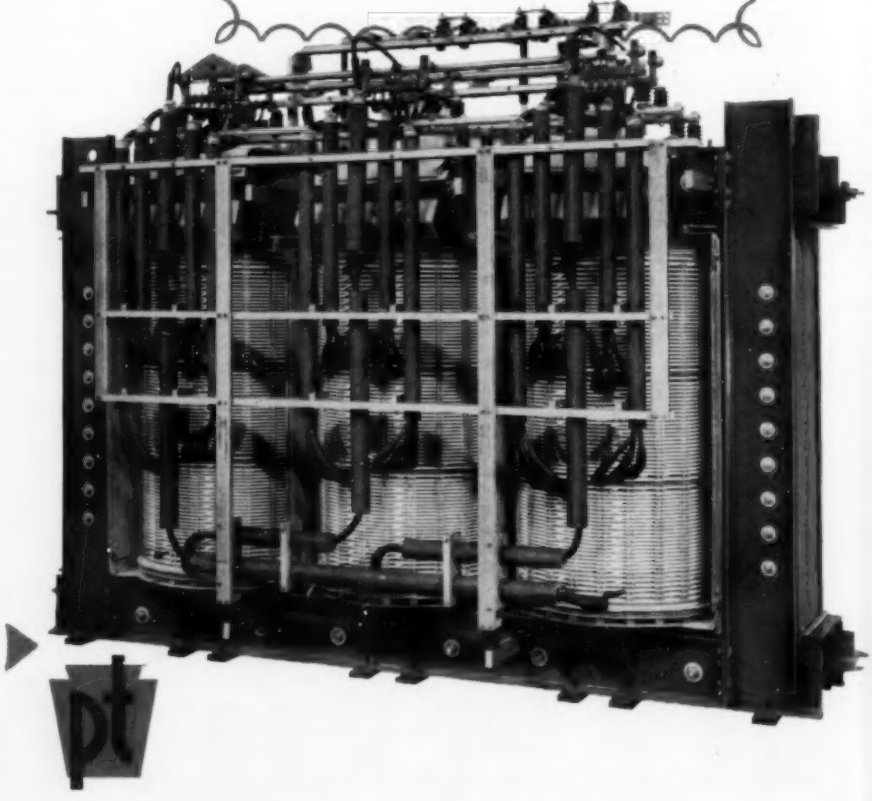


Pressures up to 600,000 pounds can be applied to coils by this Pennsylvania hydraulic press.

When a large power transformer is subjected to a short circuit, a force of several hundred thousand pounds may be imposed axially on its coils. Of course, these short circuit forces are taken into account in the design of each transformer. But at Pennsylvania, "proof on paper" is not enough. Positive action is taken to be absolutely certain that your transformer will withstand short circuits. Putting on the pressure is the added measure of safety engineered into every helical and pancake coil. Pennsylvania engineers calculate the total short circuit force that would be produced by a short circuit at the secondary terminals with the rated voltage maintained on the primary. Each coil is then compressed with this predetermined force. Finally, the coil is treated in such a manner that it will maintain its compressed size and shape when mounted on the core.

This idea, as well as this method of precompressing coils, was devised by Pennsylvania Transformer Company over 15 years ago. It has been a regular step in Pennsylvania's manufacturing process ever since then.

The fact that the transformer coils maintain their shapes under the prescribed pressure is your guarantee that the transformer will withstand short circuits.



Core and coil unit of 20,000 Kva, three phase transformer. Strong supports are provided at the top and bottom of the coils to keep the coils in their precompressed shapes. No movement can take place in these transformer coils, even under the most severe short circuit.

PENNSYLVANIA TRANSFORMER COMPANY • **BOX 330, CANONSBURG, PENNSYLVANIA**

A McGraw Electric Company Division

Controller Co. Mr. Fritzsche will serve in the company's Youngstown, Ohio, office and Mr. Lawson in the New York office.

C. G. Crawford has been appointed sales manager for Baldwin-Lima-Hamilton Corp.'s entire line of hydraulic turbines and related equipment. He will be located in Philadelphia.

James C. Addleman has joined Martindale Electric Co. as assistant sales manager. He was formerly special representative to the steel industry for Westinghouse Electric Corp.

A. M. Hatfield has retired from the mechanical division of the Acme Steel Co., and **J. M. Serra** has been named superintendent of the mechanical division at Acme.

Bruce Cramer has been appointed refractories Engineer for Mich. and Ind. by Norton Co. Mr. Cramer has been serving in the same capacity in Texas since 1954.

Obituaries

Francis W. Jessop, retired founder and president of the Ohio Electric Manufacturing Co., died December 16. Prior to organizing the Ohio Electric Manufacturing Co., Mr. Jessop had been general manager of the Electric Controller Manufacturing Co.

Edward D. Youmans, vice president in charge of research and product development of the Okonite Co., died December 18. He was 58 years old. Mr. Youmans joined the Okonite firm in 1913 as a laboratory assistant. He was named technical manager in 1928, made vice president and technical director in 1943 and vice president in charge of manufacturing and research in 1951. He was elected a director in 1952.

Sir James Dunn, 81, chairman and president of Algoma Steel Corp., died January 1.

Henry Burke, project engineer for Kaiser Engineers, died December 30. Prior to joining Kaiser Engineers, Mr. Burke was chief engineer at Harvey Aluminum Division, Harvey Machine Co., Inc.

keep production up with
AIRE-RECTIFIERS
the original Split System
CRANE CAB CONDITIONER
for Crane Cabs and Pulpits
THE LINTERN CORPORATION
ROUTE 20, EAST • PAINESVILLE, OHIO

Progress Report On Blast Furnace Gas Cleaning

Since the development work was completed five years ago, seven Pease-Anthony Blast Furnace Gas Washers have been installed and are operating. Three more are under construction and many more are in the planning stage.

The following table summarizes the performance of the operating washers:

Installation	Years Operated	Volume SCF	Pressure Drop Inches Water	Dust Loading Grains/SCF Inlet	Dust Loading Grains/SCF Outlet
A	4	78,000	30	3–19.0	.01–.04
B	3½	78,000	30	2–3	.02–.08
C	3	85,000	30–40	2–3	.01–.03
D	3	45,000	30	2	.02–.03
E	½	75,000	50	—	.003
F	½	26,000*	12	5	0.1
G	½	26,000*	12	5	0.1

Installation C is in Illinois. All others are in Pennsylvania.
*Two units in parallel on one furnace. Higher clean gas loadings due to lower available top pressure.

Users enthusiastically approve these modern washers. Typical comments from Chief Engineers, Blast Furnace Superintendents and Combustion Engineers are:

"The P-A Washer requires zero maintenance."
"No secondary cleaner required."
"Gives consistently good cleaning at all times."
"A *natural* where high top pressures are used."

For further information contact

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Technical Representatives Throughout the World
Cable Address: CHEMICONST, N. Y.

Vital Functions at the mills of Great Lakes Steel are CLARK CONTROLLED

● Throughout the huge mills of Great Lakes Steel, Detroit, Michigan, Division of National Steel Corporation, vital production and handling operations depend on Clark Control. Illustrated above, for example, is Great Lakes' mammoth stacking conveyor system, linking ship-to-shore unloading and piling of coal and limestone for blast furnaces at Zug Island. Designed and built by Hewitt-Robbins, this travelling stacker—perhaps the largest in the world, handles coal from boats at the rate of 2,500 tons per hour. To maintain production during ice-bound months, it is planned ultimately to stockpile 500,000 tons of limestone and 350,000 tons of coal . . . Clark Bulletin 6080 Reduced Voltage Starters are used on the AC drive motors for this conveyor.

Great Lakes standardized on Clark Bulletin 110 Edgewound Resistors for much of its production and handling equipment, such as this Hot Metal Crane.

Clark Control Panel and Control Center for the hot rolled steel cutting line. Note Clark Edgewound Resistors at top of panel.

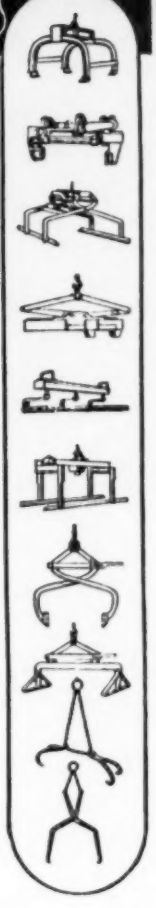
The CLARK CONTROLLER *Company*

Engineered Electrical Control

1146 East 152nd Street • • Cleveland 10, Ohio

IN CANADA: CANADIAN CONTROLLERS, LIMITED • MAIN OFFICES AND PLANT, TORONTO

MANSAVER GRABS®



AT THE SHEAR LINE

OF A LARGE STEEL PLANT

This 14 ft. Mansaver Grab, shown swinging 7 tons of steel sheet from shears to shipping—at a tremendous saving in man-hours—is but one of many Mansavers made for handling sheets of all dimensions. There are other Mansavers for handling coils vertically or horizontally.

This same saving can be had from a Mansaver to fit *your*; manufacturing or shipping department set-up. Write us for details . . . always remembering that Mansaver Grabs are built for Continuous Operating—not low first cost!

MANSAVER INDUSTRIES, INC.
3116 East St., New Haven, Conn.

THE ELECTRIC FURNACE CO. Salem, Ohio
EF
Gas Fired, Oil Fired and Electric Furnaces.

HEAT PROCESSING
FURNACES
for the Steel Industry

Equipment for annealing, normalizing, galvanizing and other heat processing of high and low carbon steel, stainless, silicon and other alloys—strip, sheet, wire, tubing and other ferrous and non-ferrous products.

Submit your problems to EF engineers
See our advertisements in preceding and following issues

THE ELECTRIC FURNACE CO.
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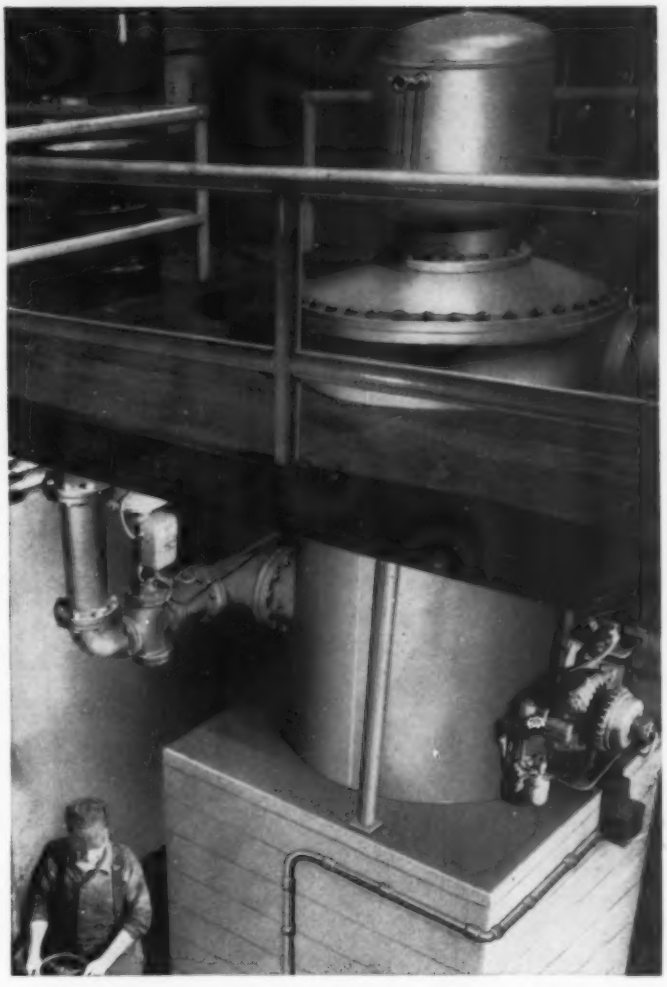
FOR ANY PROCESS, PRODUCT OR PRODUCTION



This Adams AWF filter has been protecting expensive test equipment for years . . . another example of how Adams saves money in making steel.

Here's proof positive
ADAMS FILTERS
save you money!

Several leading steel manufacturers test tubing with high pressure water from a multi-stage pump. Damage to the pump and expensive test equipment would cause costly lost production and repair bills. Frequently the R. P. Adams Company has supplied the needed protection — an Adams AWF filter.

RESULTS — Under constant production use these Adams automatic water filters have removed from the test water all foreign matter that would damage the pump and test equipment. Also, they afford a large saving in water thru recirculation.

Adams filters can save you money, too.
Write today for Bulletin 691.

R. P. ADAMS CO., INC.
223 E. PARK DRIVE BUFFALO 17, NEW YORK

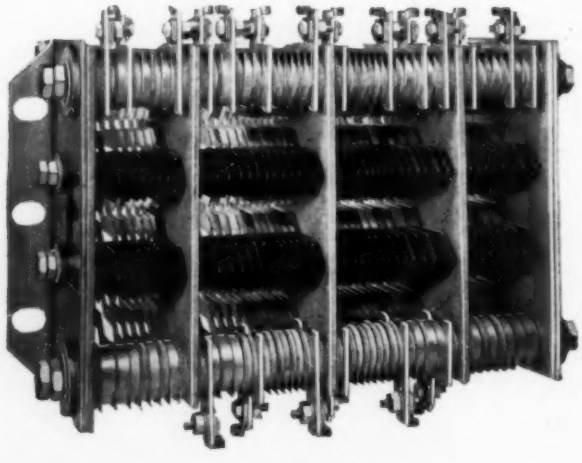
P-G Steel Grid RESISTORS

for Internal Mounting In LARGE and Small FACE PLATE CONTROLLERS

Standard units for 5 to 65 H.P. Motors

Design of the P-G Steel Grid Resistor makes it possible to supply correct ohmic values as well as ample capacity. The ability to meet **both** of these requirements is assurance of accurate control with full protection to motors using either large or small Face Plate Controllers.

All steel construction, mica insulation, provision for expansion, and ample ventilation combine to produce the exceptional stamina called for by today's production schedules.



Standard units for 2 to 25 H.P. Motors

Write for Bulletin No. 500

P-G

The Nonbreakable Steel Grid Resistor

THE POST-GLOVER ELECTRIC COMPANY

• ESTABLISHED 1892 •

221 WEST THIRD STREET, CINCINNATI 2, OHIO

Publication Service...

JANUARY, 1956

You Can Obtain...

... any of the bulletins reviewed in the Publication Service of the IRON AND STEEL ENGINEER without obligation or cost. Simply circle the desired item numbers on one of the prepaid postal cards and mail. The requests will be forwarded to the manufacturers involved who will send the bulletins to you.

Note: Post cards expire three months after publication date.

(1) Motor-Generator Sets

Large pedestal-bearing synchronous motor-generator sets for rolling mills, mine hoists, paper machine drives, etc., are described in a new bulletin released by Allis-Chalmers Manufacturing Co. The bulletin describes various construction features of these generators and motors including the frog-leg type of armature winding. It portrays typical motor-generator sets as well as examples of special combinations used to support metal rolling mill motors. Tables for standard ratings for 2 and 3-machine sets are included in the bulletin as well as motor and generator voltages, special frequencies and special combinations. (05-B 8175)

(2) Overhead Materials Handling

The Cleveland Tramrail Div., of The Cleveland Crane and Engineering Co., has released a new and completely revised booklet featuring engineering and application data. The booklet is complete with photographs and drawings, featuring a wide variety of installations and equipment details. A thorough analysis of stresses in a number of types of overhead tracks is provided. The subject of track peening is carefully covered. Track switches, carriers, tractors, cranes, transfer cranes, gantry cranes, automatic handling systems, interlocks, discharge points, electrification, buckets and grabs are also described and illustrated. (Booklet 2008-L)

(3) Wire Flattening Mills

A new 12-page illustrated booklet giving details on the wide range of 2-high wire flattening mills and auxiliary equipment has been published by Waterbury Farrel Foundry and Machine Co. The booklet points out that this equipment is custom-engineered for specific applications in flattening ferrous, non-ferrous and clad metal wire in diameters from a few thousandths of an in. up to one in. at speeds approaching 3000 fpm. Extensively illustrated, the booklet shows a variety of single and multiple stand mills built by the Waterbury Farrel rolling mill machinery division. Mill construction features covered in the text include, rolls, housings, screwdown, universal joints, drive and lubrication. Approximately half of the booklet is devoted to the auxiliary equipment mill installation. Illustrations and text give detailed information on payoffs, edgers, winders, dancer roll control stand, coolant systems, and various optional features. (Circular No. 731-R)

(4) Refractories

A new 32-page catalog featuring engineering data on the application of Plibrico refractories in industrial furnaces and boilers has been published by Plibrico Co. In addition to descriptions and illustrations of typical applications, a valuable material application chart is included.

(5) Levelers

A bulletin on the Voss levelers built by E. W. Bliss Co. by special arrangement with Voss Engineering Co. describes both inverted and chain-type levelers and their applications. The bulletin explains how these levelers, based on the famous Ungerer patents, will flatten to stretcher-leveler flatness all metal thickness from fine gage strip to armor plate. (Bulletin No. 41)

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IRON & STEEL ENGINEER

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52	ALLIANCE MACHINE CO.		Sheet carrier.
53	ASKANIA REGULATOR CO.	BULLETIN NO. 161	Edge position control.
54	BAILEY METER CO.	SPEC. E12-5 AND E65-1	Analyzer-recorder on combustion economy.
55	BEARINGS, INC.		Bearings and bearing accessories.
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57	CHANDEYSSON ELECTRIC CO.		Steel mill bulletin.
58	CLARK EQUIPMENT CO., INDUSTRIAL TRUCK DIVISION		Industrial applications of carriers.
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66	GENERAL ELECTRIC CO.	GEA-5994	Limit switches.
67	GENERAL ELECTRIC CO.	GEA-6307	Drum switches.
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69	HARNISCHFEGER CORP.		P&H overhead cranes.
70	HOMESTEAD VALVE MANUFACTURING CO.		High pressure steam cleaner.
71	HYATT BEARINGS DIVISION, GENERAL MOTORS CORP.	CATALOG NO. 150	Cylindrical roller bearings.
72	I-T-E CIRCUIT BREAKER CO., SWITCHGEAR DIVISION	BULLETIN 7004	Descriptions of 5, 7.5 and 15 kv switchgears.
73	INDUSTRIAL GEAR MANUFACTURING CO.	BULLETIN NO. 155	Description of their plant and operations.
74	KOPPERS CO., INC., FAST'S COUPLING DEPT.		Engineering drawings, capacity tables, etc. on couplings.
75	LEEDS AND NORTHRUP CO.	FOLDER ND46-91(5)	Unitized O_2 gas analyzer.
76	LINK-BELT CO.	BOOK 2619	Parallel shaft gear drives.
77	LUBRIPLATE DIVISION, FISKE BROTHERS REFINING CO.		Lubrication.
78	MINNEAPOLIS-HONEYWELL REGULATOR CO.	CATALOG 1531 AND BULLETIN 8420	Control with electronic instrument and electronic relay
79	NORTHERN ENGINEERING WORKS	BULLETIN SE-108	Overhead electric traveling cranes.
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81	PITTSBURGH LECTROMELT FURNACE CORP.	CATALOG NO. 9-A	Lectromelt furnaces for melting and refining.
82	POST-GLOVER ELECTRIC CO., THE	BULLETIN NO. 500	Steel grid resistors.
83	RAMTITE CO., THE		Castable and gunning refractories.
84	RUST FURNACE CO.		Furnace information.
85	SPRAYING SYSTEMS CO.	DATA SHEET 6120	Descaling spray nozzles.
86	TAYLOR INSTRUMENT COMPANIES	BULLETIN NO. 98262	Potentiometer transmitter.
87	S. G. TAYLOR CHAIN CO.	BULLETIN NO. 90	Alloy steel hooks.
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89	WAGNER ELECTRIC CORP.	BULLETIN MU-202	General purpose motors.
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91	YODER CO., THE		Economics and mechanics of slitter operations.

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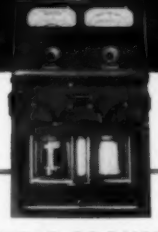
THIS IS INLAND STEEL!

The Cities Service Heat Prover Works Here



THE PORTABLE HEAT PROVER is supplied and maintained free by Cities Service. It helps control combustion efficiency by allowing rapid, continuous sampling, simultaneous readings and direct measurement of oxygen and combustibles. Inland uses the Heat Prover for its blast furnaces, open hearths, soaking pits, continuous galvanizing line, reheat furnaces, purging operations, annealers, and boilers on ore ships.

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QUALITY PETROLEUM PRODUCTS

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FOR YOUR
cleaning jobs...
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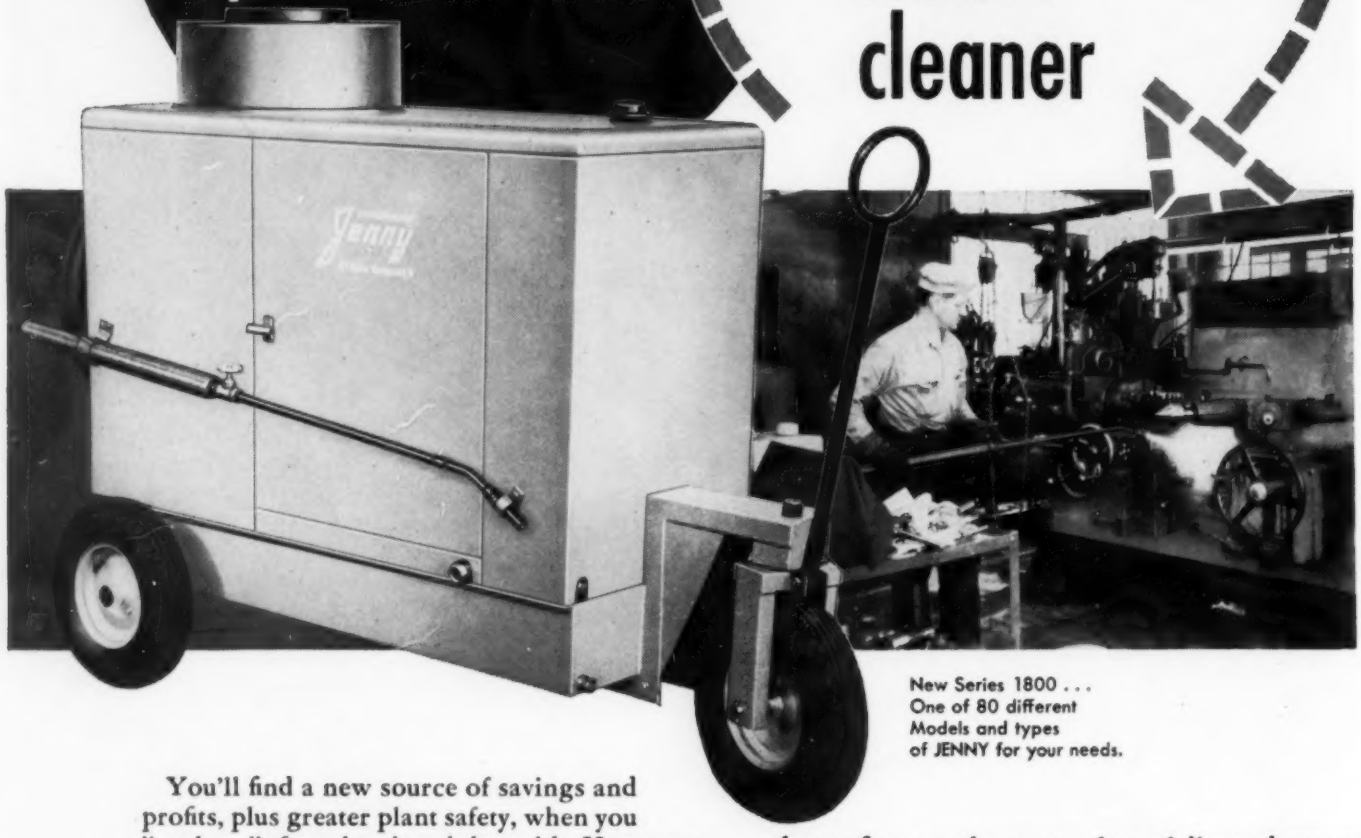
with
HYPRESSURE
Jenny
steam cleaner



New Series 1800 . . .
One of 80 different
Models and types
of JENNY for your needs.

You'll find a new source of savings and profits, plus greater plant safety, when you "tool up" for cleaning jobs with Hypressure Jenny Steam Cleaner. Jenny removes grease, cutting oils, and protective coatings from machinery, equipment, sub-assemblies, and castings, before repair, repainting or machining—and does it ten times faster than by ordinary methods! It promotes safety by eliminating the fire hazard of greasy conveyor chains and floors, and the use of inflammable cleaning solvents. It cleans ribbed glass windows for better illumination; keeps floors and runways free of dirt and grease for safer, faster plant traffic. Jenny steam cleaning often reveals damaged or worn parts for repair before costly production delays or breakdowns occur. In fact, Jenny does most any cleaning job for one-tenth the cost of cleaning by hand. So find out how easy it is to bring these savings and safety to your plant.

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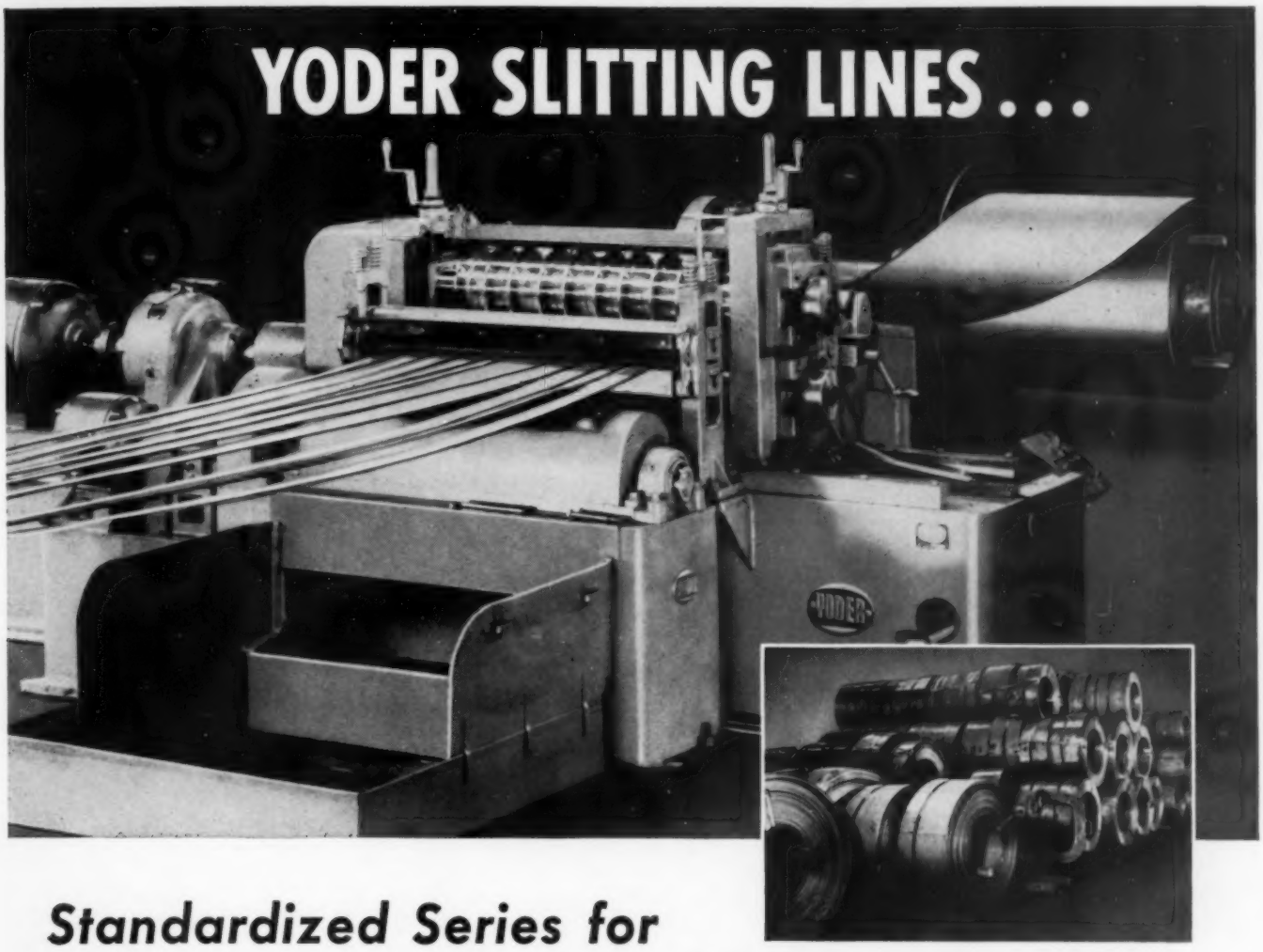
"Serving Since 1892"
P.O. BOX 21 CORAOPOLIS, PA.

YODER SLITTING LINES...



Standardized Series for
LOW FIRST COST AND OPERATING COST!

A relatively small, low-cost Yoder slitting line offers attractive savings possibilities and high production in slitting small and medium coil sizes and strip gauges. Yoder has standardized a series of such machines, affording a rare combination of low cost and productive capacity amply sufficient for the needs of the great majority of sheet metal fabricators and custom slitting shops. Supplementing the standardized series are *special models for slitting big coils and heavy gauges at high speeds.*

For requirements as low as 100 tons per month, one of the standardized Yoder slitting lines will pay for itself in short order. The savings PER TON increase rapidly with decrease in coil size and width of strands to be slit.

Another important advantage gained by fabricators having their own slitter is the ability, from a relatively small stock of standard width coils, to meet expected and unexpected needs for slit strands in a few hours. This means easier production planning and greatly reduced strip inventories, in addition to lower prices and quicker deliveries of their strip purchases.

Yoder Slitter Book contains basic information on the economics and mechanics of slitter operation, with time and cost studies, production records and other valuable data. Send for it.

THE YODER COMPANY • 5495 Walworth Ave. • Cleveland 2, Ohio

ENGINEERING YODER MANUFACTURING

ROTARY SLITTING LINES

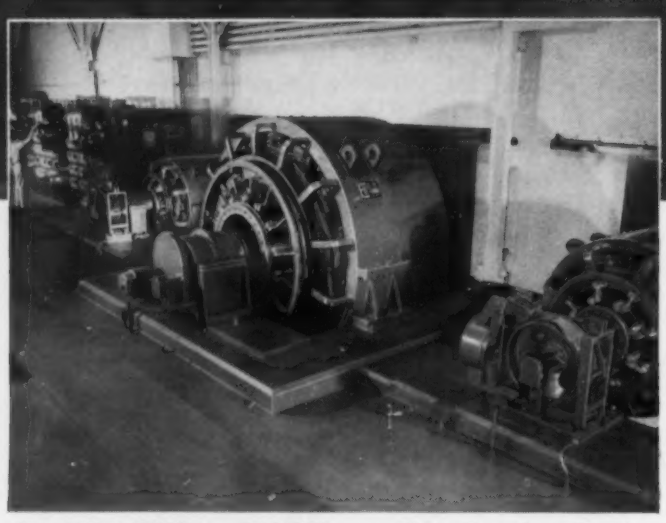
COLD ROLL FORMING MACHINES

ELECTRIC-WELD PIPE AND TUBE MILLS

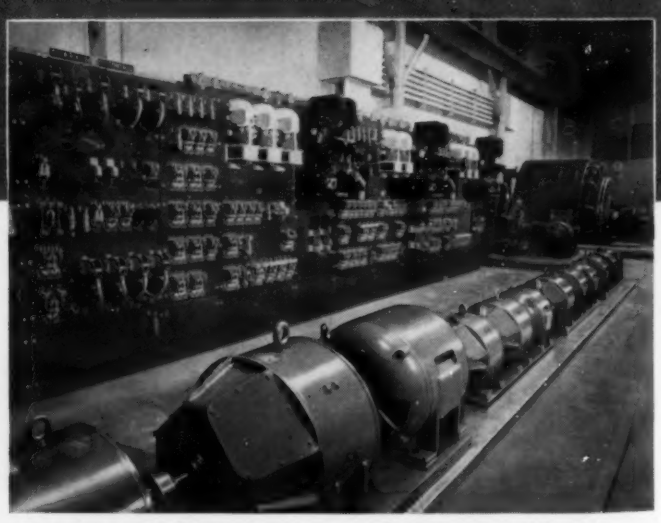
ELLIOTT

...setting the pace

The Bliss 4-high, single-stand cold reduction reversing mill. Mill produces cold-rolled strip.



The Elliott 3000-hp, 150/375-rpm, 600-volt main mill drive motor (middle), is flanked by two special low inertia 1000-hp, 300/900-rpm, 600-volt motors with magnetic brakes which furnish power to the reels.



The d-c control board—the complex nerve center of all the d-c machines. Elliott C-W exciter sets are in the foreground. Elliott engineered the complete job, including switch-gear, controls and rotating equipment.

rotating electrical equipment!

NEWPORT STEEL CORPORATION'S NEW REVERSING COLD MILL

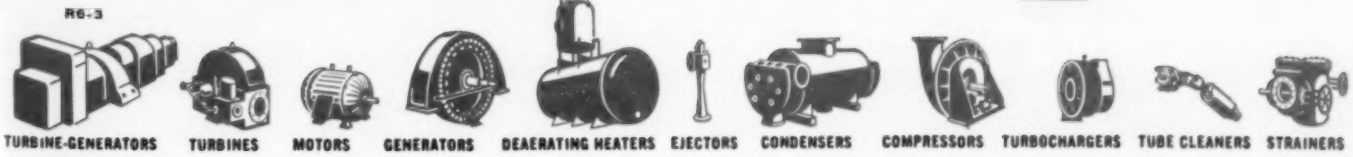
When Newport Steel dedicated its new four-high reversing cold mill in January, 1955, it marked not only the completion of one of the most modern and advanced mills of its kind but also a record-breaking construction and installation job. Erection of the mill began August 30th, and the *first test run of steel was rolled three months later!*

Part of the story behind this rapid completion can be found in the speed and efficiency of Elliott application engineering and manufacturing. *Elliott furnished and engineered all electrical apparatus, including controls, switchgear and ventilating equipment.* Pictured below are some of the large Elliott rotating electrical equipment, including the main m-g set, the 3000-hp main mill drive motor, the reel motors, and a number of auxiliary motors and other machines.

The application of Elliott equipment on jobs like this is coordinated by the Elliott Industry Engineering Department, which includes men with extensive experience in steel and related fields. For complete, up-to-the-minute information on Elliott steel mill equipment, write Elliott Company, Ridgway, Pennsylvania.

The Elliott motor-generator set. At left, the two 800-kw, 600-volt d-c generators (one for each reel drive motor). In the center, the 4500-hp, 13,200-volt, 514-rpm synchronous motor driver and, at right, the 2500-kw, 600-volt d-c generator which serves the main mill motor.

ELLIOTT Company



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FOR SKIN PASS MILLS

IN ELECTROLYTIC, GALVANIZING, SILICON, STAINLESS, ETC.

THE ALL PURPOSE ROLLS

*SPEC

PLASTIC COATED ROLLS

last 3 to 5 times longer than ordinary covered rolls

SPEC Pinch Rolls, Billy Rolls, Deflector Rolls, Pressure Rolls, Carrier Rolls, etc., are giving miraculous results in leading skin pass mills for continuous strip, electrolytic tin, galvanizing, silicon, stainless, etc. Operating speeds up to 4000 FPM . . . Heat resistant up to and exceeding 500° F. . . . Acid- oil- and grease-resistant . . . Coefficient of friction .35.

STRENGTH • DURABILITY • LIFE
never before achieved in covered rolls

Switch to SPEC rolls for reduced downtime—lower maintenance cost—increased production. Made with a variety of different characteristics to meet specific conditions. WRITE, WIRE or PHONE for details and applications.

Write us or contact one of these SPEC Representatives for SPECialized Roll Service

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8226 Buchanan Street, St. Louis 14, Missouri
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275 James St. North, P. O. Box 23,
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STEEL PLANT EQUIPMENT CORP.
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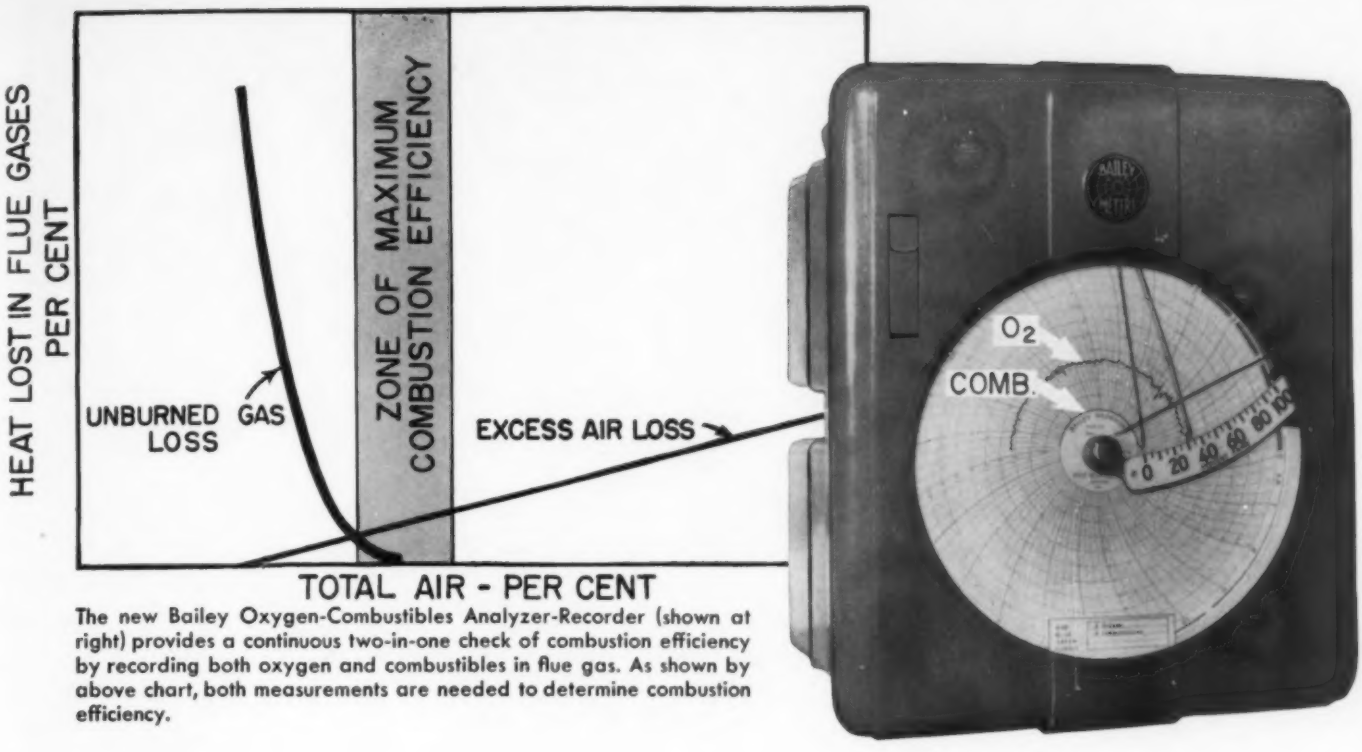
4

ANNEALING • PICKLING • SCRUBBING • FINISHING • ELECTRO-TINNING



The new Bailey Oxygen-Combustibles Analyzer-Recorder (shown at right) provides a continuous two-in-one check of combustion efficiency by recording both oxygen and combustibles in flue gas. As shown by above chart, both measurements are needed to determine combustion efficiency.

BAILEY announces · · · New 2 in 1 way to measure Combustion Efficiency

The new Bailey Oxygen-Combustibles Analyzer-Recorder gives you a continuing double check on combustion economy. It's fast response measures and records:

1. Excess air—regardless of the fuel or combinations of fuels being burned.

2. The mixing efficiency of your fuel-burning equipment—by indicating the amount of combustibles in your flue gas, resulting from incomplete mixing of fuel and air.

Combustion efficiency depends upon fuel-air ratio. Too much fuel can be even more costly than too much air. And because of the interdependence of these two factors, no control that measures only one of them can give you complete protection.

Now, for the first time, you can check *both* with a *single* fast acting instrument, using the new Bailey Oxygen-Combustibles Analyzer-Recorder for industrial furnaces, kilns, heaters and boilers.

Fuel economy improves as excess air is reduced —until unburned fuel begins to show up in the flue gas. When this happens, combustion efficiency drops off sharply if there are further decreases in the air-fuel ratio. That's why combustion gases must be analyzed for *both* oxygen and combustibles to get a true indication of efficiency—and that is why Bailey coordinates both measurements on the same chart, to show when excess air may be reduced safely without danger of greater losses from unburned gases.

The Bailey Oxygen-Combustibles Analyzer is an approved combustion safeguard.

Ask your local Bailey engineer for suggestions on application. Equipment details in Product Specifications E65-1 and E12-5. P31-1

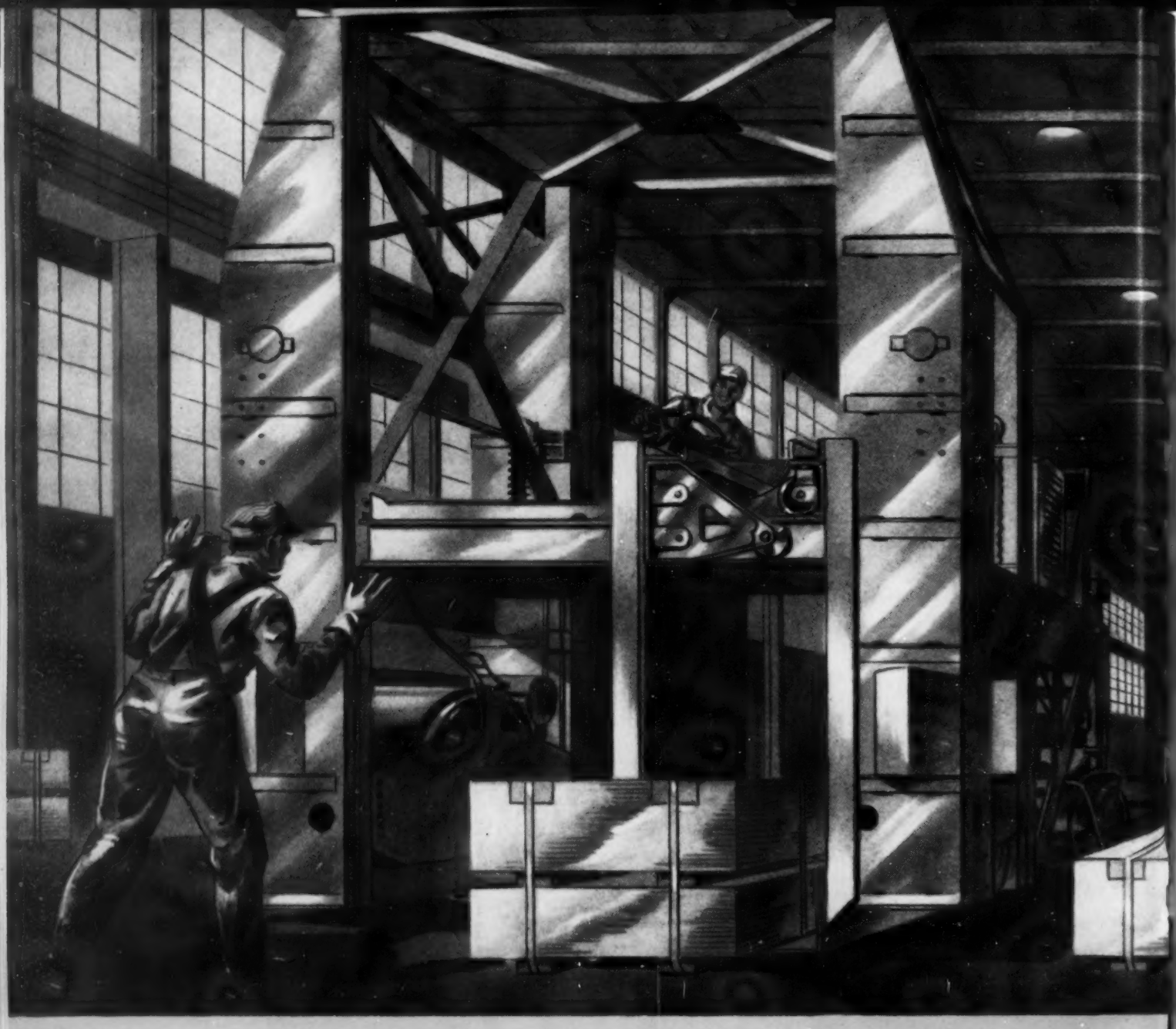
BAILEY METERS

BAILEY METER COMPANY

1047 IVANHOE ROAD • CLEVELAND 10, OHIO

INSTRUMENTS AND CONTROLS

For Power And Process



Alliance Sheet Carriers...

KEEP YOUR SHEETS ON THE MOVE

Alliance
SHEET CARRIER

● The big **Alliance Sheet Carrier** moves sheets when and where you want them—travels from building to building; handles loads as heavy as those moved by light cranes and does crane duty in buildings where light construction makes cranes impractical. It's stable, easy to operate and highly maneuverable. We build to the capacity you specify with diesel-electric or gasoline-electric power. Specifications include hydraulic lift, clamp and steering. Write for details. Let us show you how the **Alliance Sheet Carrier** can eliminate delays and keep floors clear in your plant.

THE ALLIANCE MACHINE COMPANY

FOUNDED 1901 — MAIN OFFICE • ALLIANCE, OHIO

Give Us The Runway
And We'll Lift The World

Manufacturers of:
LADLE CRANES • GANTRY CRANES • FORGING MANIPULATORS • SOAKING PIT CRANES • STRIPPER CRANES • SLAB AND BILLET CHARGING MACHINES • OPEN HEARTH CHARGING MACHINES • SPECIAL MILL MACHINERY • STRUCTURAL FABRICATION • COKE PUSHERS • ORE BRIDGES • SHEET CARRIERS

Equipment News...

INDUCTION HEATERS

▲ Introduced by General Electric Co. is a line of electronic-type induction heaters, featuring a total of 16 models in four output ratings for brazing, soldering, surface hardening, and annealing.

The new line consists of induction heaters which have been rated: 7½-kw, 15-kw, 25-kw, and 40-kw output. Each heater model is offered with combinations of thyratron power control, built-in output transformer, or tapped-tank coil. The resulting flexibility makes these heaters adaptable to a wide variety of induction heating loads and applications.

Additional features of the new heaters include dustproof cabinets, separate aluminum enclosures for oscillator units. Also, longer tube life can be realized since filament-voltage is regulated with constant-voltage transformer.

Voltage regulation of oscillator and rectifier tube filaments maintain voltage within plus or minus three per cent of rated value when the induction heaters are operated at specified line voltage. Panel control instruments for the new units include plate-current ammeter, grid-current ammeter, filament voltmeter, and tube filament hour meter.

Protective devices provided are: overload relay in high voltage d-c plate supply, fused control circuit, time-delay relay for tube warm-up, water flow interlock switch, overtemperature interlock switch, and interlocked access doors which help protect the operator from high voltage.

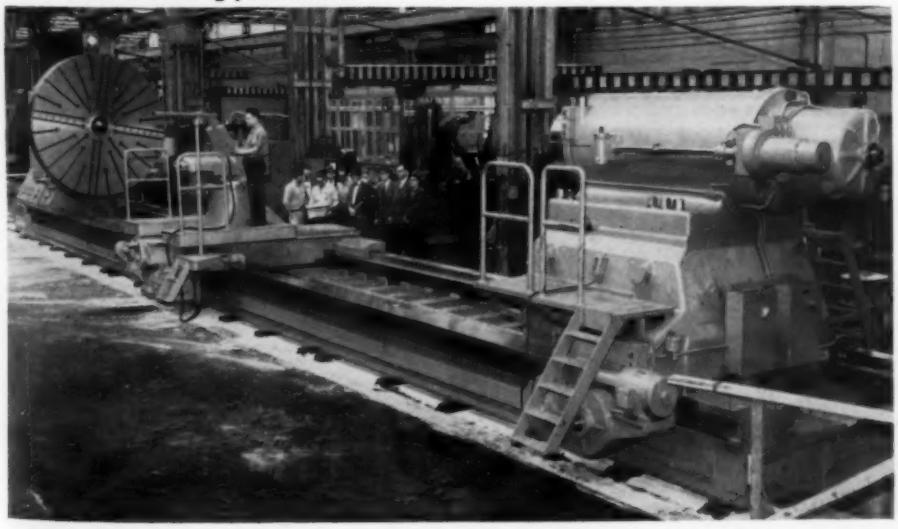
BATTERIES

▲ Introduced by Exide Industrial Division of the Electric Storage Battery Co. is a new line of flat-plate motive power batteries to complement its long-life tubular plate Exide-Ironclad industrial battery line. Using the trade name Exide-Powerclad, they are described as premium flat-plate batteries with triple insulation.

Claimed to be the best flat-plate power buy, the new batteries are for use in electric industrial fork and lift trucks, mine locomotive power and marine applications.

GE INSTALLS GIANT 144-IN. SWING LATHE

This Betts-Bridgeford lathe, built by the Consolidated Machine Tool Corp., division of Farrel-Birmingham Co., has been installed in the General Electric Co.'s Large Motor and Generator Department at Schenectady, N. Y. The lathe boasts a 144-in. swing and 55-ft between centers. The live tailstock quill center is accurate to a total indicated runout of .0005 in. All-electronic longitudinal and cross feeds permit feed settings at any increment from .002 in. to .75 in. per spindle revolution. The machine can carry jobs weighing up to 200 tons at speeds ranging from one-half to 40 rpm. Centers alone will carry 200-ton loads at slow speed while steady-rests are being positioned.



CONNECTORS—COUPLERS

New solderless electrical connectors and couplers are now standard equipment on circular all-welded lifting magnets built by the Electric Controller & Mfg. Co. Coupler shown at top is used a short distance after electrical lead leaves the magnet terminal box. Clasp-type connector, shown at bottom, is used to join magnet electrical lead with lead to controller and power source.

Powerclad positive plate grids are constructed of "Silvium," Exide's patented corrosion-resistant alloy. Vitrex and perforated polyvinyl chloride retainers, uniquely wrapped and fastened, a polyethylene insulating strip and a deeply grooved microporous rubber separater are used to achieve superior positive plate insulation.

DIAL THERMOMETER

▲ Announcement by Taylor Instrument Companies is a bimetallic dial thermometer for a wide variety of applications. Called the bi-therm dial thermometer, it is offered for such industrial and institutional services as pipe lines, hot water tanks, storage tanks, ovens and air ducts.

Easy to read, economical in price, rugged, and accurate within plus or minus 1 per cent of range over the entire range, it is available with three or five inch dials and stem lengths of 4, 6, 9, and 12 inches. Separable wells of brass, steel, type 304 stainless steel, or Monel are available. Ranges of the various instruments run from minus 40 to plus 750 F. All exposed metal parts are of arc-welded corrosion-resistant stainless steel.

Instruments are waterproof and mechanical connections are welded

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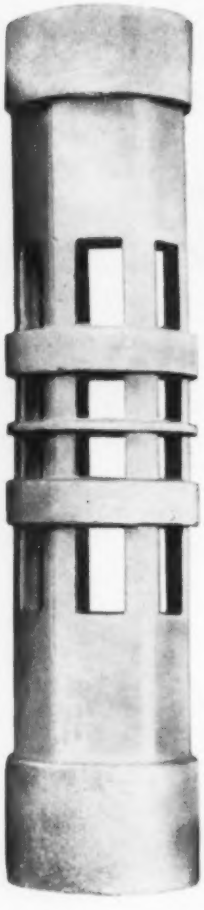

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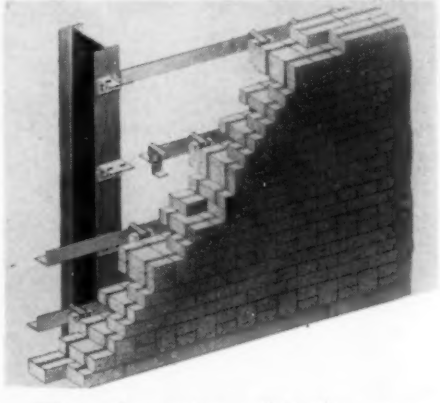
for greater toughness and reliability. There is no ambient temperature effect. Over range protection is 50 per cent up to 500 F and 10 per cent above 500 F. All instruments, except for the unit having the 200 to 750 F range are silicone-damped against vibrations. This results in increased speed of response, absence of zero shift due to shock, minimum pointer vibration, and elimination of pointer chatter when the thermometer is handled.

MODULAR SUSPENDED WALL

▲ A new modular suspended wall designed to replace existing solid masonry walls for slab and billet heating furnaces in the steel mills, as well as for use in boilers has been announced by G. P. Reintjes Co.



The refractories, with the exception of the supporting tiles are 2½ x 4½ x 9 in. in size. The individual tiles are locked together by tongues and grooves. Every other course is a header course laid in what is known as the "English Bond." The walls are laid in the same type of high temperature mortar that most of the wall companies have for years been using to absorb the expansion of the refractories.

This modular wall can be insulated. It can be built within the steel casing and can be supported from existing buck stays with a minimum of structural change. New furnaces do not require steel casings. This wall can be used to replace areas of existing solid refractory furnaces where the present maintenance cost is heavy and the tiles can be bonded to your present brick work.

The design of the refractories is such that they can be shipped on skids. They will nest together requiring a minimum of space in storage. The tiles can be furnished in No. 1

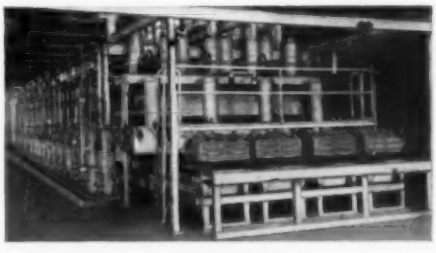
How to Select the Most Economical Insulating Firebrick

The advantages of lightweight insulating firebrick over ordinary "heavyweight" firebrick are generally known to furnace operators and furnace builders. But many buyers have wondered just what advantages there might be in one brand of insulating firebrick as against another. The answer to this question could very well mean savings in fuel costs, increased furnace output, longer life . . . or all three.

One furnace builder ran tests on their small electric kilns where heat input could be measured with great accuracy. Here's what they found: B&W IFB required 25% less heat than any other brand of insulating firebrick they tried.

The reason? B&W IFB are lighter in weight than any other insulating firebrick — they contain more tiny, insulating air cells. Heavier, denser insulating firebrick linings waste fuel two ways: They soak up and store more heat which is lost when the furnace is cooled; and they conduct more heat through the walls.

How about long life? One of the



toughest tests of firebrick is in the lining of a carbon monoxide furnace. Some brands last only a few weeks, then disintegrate, due to iron oxide impurities in the brick which react with the gas.

But B&W Insulating Firebrick contain little iron oxide, and they're processed at high temperatures so that any traces of iron oxide form stable compounds. So instead of deteriorating they stay on the job year after year —in many cases over 10 years.

Another factor, important to many furnace operators, is accurate temperature control. Here again B&W IFB have an advantage over other insulating firebrick. First, because B&W IFB are lighter in weight they store and conduct less heat—and they respond more quickly to changes in heat input.

A typical example is the giant stress-relieving furnace shown below—sixty feet by twenty-two feet by seventeen feet high. The B&W lining plays a vital part in holding the desired temperature within 5 degrees accuracy!

Next time you buy or specify insulating firebrick, remember that the lightest weight brick of all—B&W—has the highest insulation value, the longest life and the greatest furnace heat controllability.

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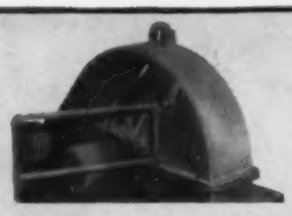

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quality, superduty quality or 60 per cent alumina clays as the service warrants.

DISC VALVE

▲ A 125-lb brass rising stem double wedge disc valve known as No. 430 has been redesigned by Crane Co.

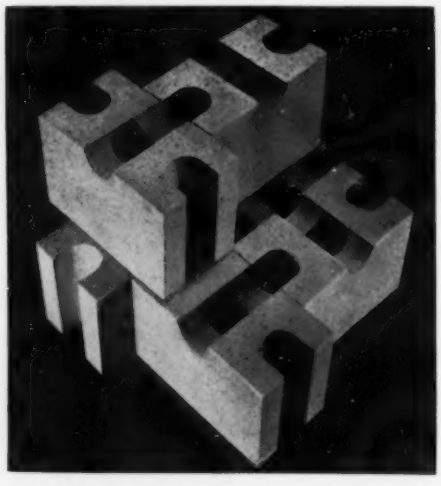
The valve is recommended for general service on steam, water, oil or gas lines. It comes in sizes ranging from ¼ in. through three in.

The body neck in the new design is cylindrical. The design offers maximum strength in the body structure thus eliminating the need for massive wall sections.

It affords a compact, relatively lightweight valve, yet ideal for resisting internal pressures. The cylindrical reinforces the seat area against the wedging of the disc and safeguards against distortion of the body in seating the disc.

CHECKER

▲ Introduced by William M. Bailey Co., is a new type of checker shape for lining and relining blast furnace hot stoves. This Kennedy checker is of three-hole design, and is laid in basket weave style.



The Kennedy checker has unobstructed flue openings and 1¼ in. minimum wall thickness. It can be supplied with or without cross flue.

The Kennedy checker produces a solid 1¼ in. wall between each flue. It is said to provide from 25 per cent to 50 per cent greater heating surface than other basket weave checkers. It is produced in two styles, one with a cross flue feature and the other without cross flue.

Increased heating surface provided

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by this checker results in a correspondingly lower stack temperature. This makes possible the use of a steel bottom for supporting the checker system, rather than brick arches required by higher stack temperatures prevailing with plain basket weave design checkers.

LIFTERS

▲ A new line of coil lifters which is available with either a manual hydraulic lift or an electro-hydraulic lift has been announced by Lewis-Shepard Products, Inc.

The new lifters have a V-shaped platform 41½ long x 30 in. wide with a lowered height of eight in. and a vertical lift of 18 in. They can handle coils weighing up to 4000 lb and having diameters up to 48 in. The lifter is used to place coils on slitter mandrels and is equipped with ball-bearing mounted flanged wheels so that it can ride on tracks adjacent to the slitter.

The manually operated unit is equipped with a double-acting hand pump which requires 50 strokes for the full 18 in. lift. The electro-hydraulic unit consists of an electric lift motor, a high pressure three-piston pump and a hydraulic cylinder. It is equipped with a throttle valve control for inching. All hydraulic components are L-S designed and manufactured. The plunger of the lift cylinder is chrome-plated and the spring-loaded chevron type packings are self-adjusting for wear. For safety, dual lift chains are also furnished.

DRIVES

▲ Introduced by Link-Belt Co. is a completely new line of Gearmotors and Motogears, in keeping with new NEMA motor sizes which deliver more hp per lb.

Compactness is achieved through a unique arrangement of hardened gears. Ratio changes are simplified through the use of only one low-speed gear set per drive size. All operating parts are readily accessible.

Quiet operation is inherent in these drives, resulting from precision machining and the use of rugged cast iron housings.

Oil-tight design is accomplished by means of a one-piece housing with just an input cover and two shaft openings. Effective seals retain oil and prevent dirt from entering the housing.

An integral, positive-locking backstop is available and can be readily installed at any time without additional parts or modifications.

The units are rated in accordance with AGMA standards. The Gearmotors range up to 30 hp and the Motogears up to 60 hp. Output speeds range from 280 rpm down to 6 rpm.

Gearmotor, with rabbet-fit, flange-mounted NEMA motor, maintains positive and permanent motor alignment, providing quiet, dependable service whether mounted on the floor, wall or ceiling. The flange is standardized, one size per motor rather than two or more, to permit use of a more universally applicable motor.

The Motogear is designed for applications destructive to ordinary gear drives — where heavy shock loads must be handled without damaging effect, and where continuous operation makes downtime especially costly.

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The motor can be replaced quickly, merely by removing four bolts and separating the coupling. Draining of oil is unnecessary. The motor mounting bracket design facilitates rapid motor realignment.

TUNGSTEN ELECTRODE

▲ A two per cent thoriated tungsten electrode for tungsten inert gas welding has been introduced by the Tungsten and Chemical Division of Sylvania Electric Products Inc.

In specific applications, the new electrode is superior to one per cent thoriated electrodes, giving easier arc starting, more stable arc, higher current capacity, longer life, and increased resistance to weld pool contamination.

Book Reviews . . .

"ASTM Specifications For Steel Piping Materials," 432 pages, heavy paper cover, 6 by 9 in., price $4.00, contains the latest approved form of 58 ASTM specifications for ferrous pipe, tubes, castings, fittings, and bolting materials. Of these standards, 47 have been revised this year. Copies of this publication can be obtained from American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

"ASTM Standards on Plastics (D-20)" October 1955, 790 pp, 6x9, heavy paper cover, $5.75, is a compilation which presents in convenient form ASTM standards and tentative specifications, methods of analysis, methods of physical testing, recommended practices, and definitions of terms pertaining to plastics. It has been substantially revised since the previous edition was published in May, 1954. Of the total of 143 specifications and tests, four are entirely new and 41 have been either revised, reaffirmed or advanced from tenta-

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Our doctors still don't know *why*, but if you are a man over 45 you are six times as likely to develop lung cancer as a man of your age twenty years ago. They *do* know, however, that their chances of saving your life could be about *ten times* greater if they could only detect cancer long before you yourself notice any symptom. (Only 1 in every 20 lung cancers is being cured today, largely because most cases progress too far before detected.)

That's why we urge that you make a habit of having your chest X-rayed every six months, no matter how well you may *feel*. The alarming increase of lung cancer in men over 45 more than justifies such precautions. Far too many men die *needlessly!*

Our new film "The Warning Shadow" will tell you what every man should know about lung cancer. To find where and when you can see this film, and to get life-saving facts about other forms of cancer, phone the American Cancer Society office nearest you or simply write to "Cancer"—in care of your local Post Office.

American Cancer Society

tive status to standard. Two others have been discontinued, one has been replaced, and another has been redesignated as a general method applicable to materials other than plastics.

This compilation of Standards on Plastics is one of a series of special compilations of standards on specific materials. It may be purchased from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

"Technical Publications," by C. Baker has just been published by John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. The book contains 302 pp., 5½ x 8½-in., cloth bound and sells for $6.00. This is a complete guide to the writing of technical publications designed to show how to go about writing technical information for industry. Its primary concern is with scientific occupations, especially engineering. It serves as a guide for presenting information verbally and graphically, but is not a textbook on English grammar or commercial art. This book outlines the needs for the user of technical publications and presents useful techniques for gathering of information, writing of text, preparing hand-drawn and photographically produced illustrations, and reproducing the work by various duplicating and printing processes.

"Hydraulic and Pneumatic Operations of Machines," by H. C. Town published by the Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y., contains 191 pp., 5½ x 8¾-in., is cloth bound, price $7.50. This book has two parts, the first of which describes the advantages and limitations of oil for power transmissions and shows the main types of pumps used. It discusses the application to various types of machines including machine tools and presses plus circuit diagrams. Other items included are the hydraulic rotary drive, features of the general design of cylinders, pipe lines, valves and protection devices, and modern accumulator systems. The second part discusses subjects dealing with pneumatic developments, air compressors and structural details, the operation and maintenance of pneumatic circuits, and air-operated jigs and fixtures.

(*Please turn to page 240*)

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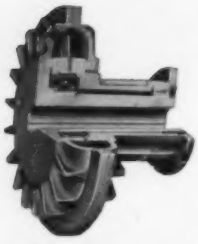

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BOOK REVIEWS

(*Continued from page 237*)

"Specifications And Tests For Electrodeposited Metallic Coatings," 104 pages, heavy paper cover, 6 by 9 in., price $1.85, is a compilation of 17 specifications, methods of test, and recommended practices embodying the work of ASTM Committee B-8 on Electrodeposited Metallic Coatings. These ASTM Standards in the field of electrodeposition of metals have either been developed jointly with the American Electroplaters Society, or have had subsequent endorsement by this group. Copies of this compilation are available from ASTM headquarters, 1916 Race Street, Philadelphia 3, Pa.

"Compact Heat Exchangers," by W. M. Kays and A. L. London, has just been published by The National Press, Palo Alto, Calif. It contains 156 pp., 8½ x 11-in., is cloth bound and sells for $5.00. This book is a comprehensive treatment of compact heat transfers including tube banks, plate-fin surfaces, finned tube surfaces, and screen and sphere matrix surfaces. In all, basic heat transfer and flow friction test data are given for a total of 88 surface configurations. A number of analytical solutions for abrupt contraction and expansion pressure loss co-efficients, laminar-flow heat transfer in circular and rectangular tubes are given. The book is written to make readily useful to heat exchanger designers the results of experimental and analytical work on compact heat-transfer surfaces.

"The Modern Building Encyclopaedia," N. W. Kay, technical editor, and published by the Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y., contains 768 pp., 5¼ x 8¾-in., is cloth bound and is priced at $15. This encyclopaedia contains the work of over thirty experts with considerable experience, some in lecturing and instructing. It has been designed to cover the requirements of the contractor, the craftsman, the student and the apprentice. Contained herein are 4,000 A to Z entries which form a complete and fully up-to-date guide to the terms used in the theory and present-day building techniques. The entries are not confined to simple definitions, as many consist of broad introductions to such subjects as architecture, plastics and prefabrication while others describe detailed work involved in arch construction, plastering and chaining.

"Safety in Industry," by D. I. Macfarlane, has very recently been published by the Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. This book contains 71 pp., 5¾ x 8¾-in., cloth bound, price $6.00. This book is a general introduction to the subject of industrial safety and gives details of a number of means whereby plant and premises can be made safer and personal protective measures more effective. It covers subjects dealing with dangers of rotating machinery and the need for guards on presses; the control of dust and fumes; protective clothing; precautions against skin diseases, damage to the eyes and harmful radiations; good lighting and flooring. Over 70 photographs and diagrams bring out results of neglect of simple precautions. This book will be of interest to employers, safety officers, factory medical staffs and to the worker himself.

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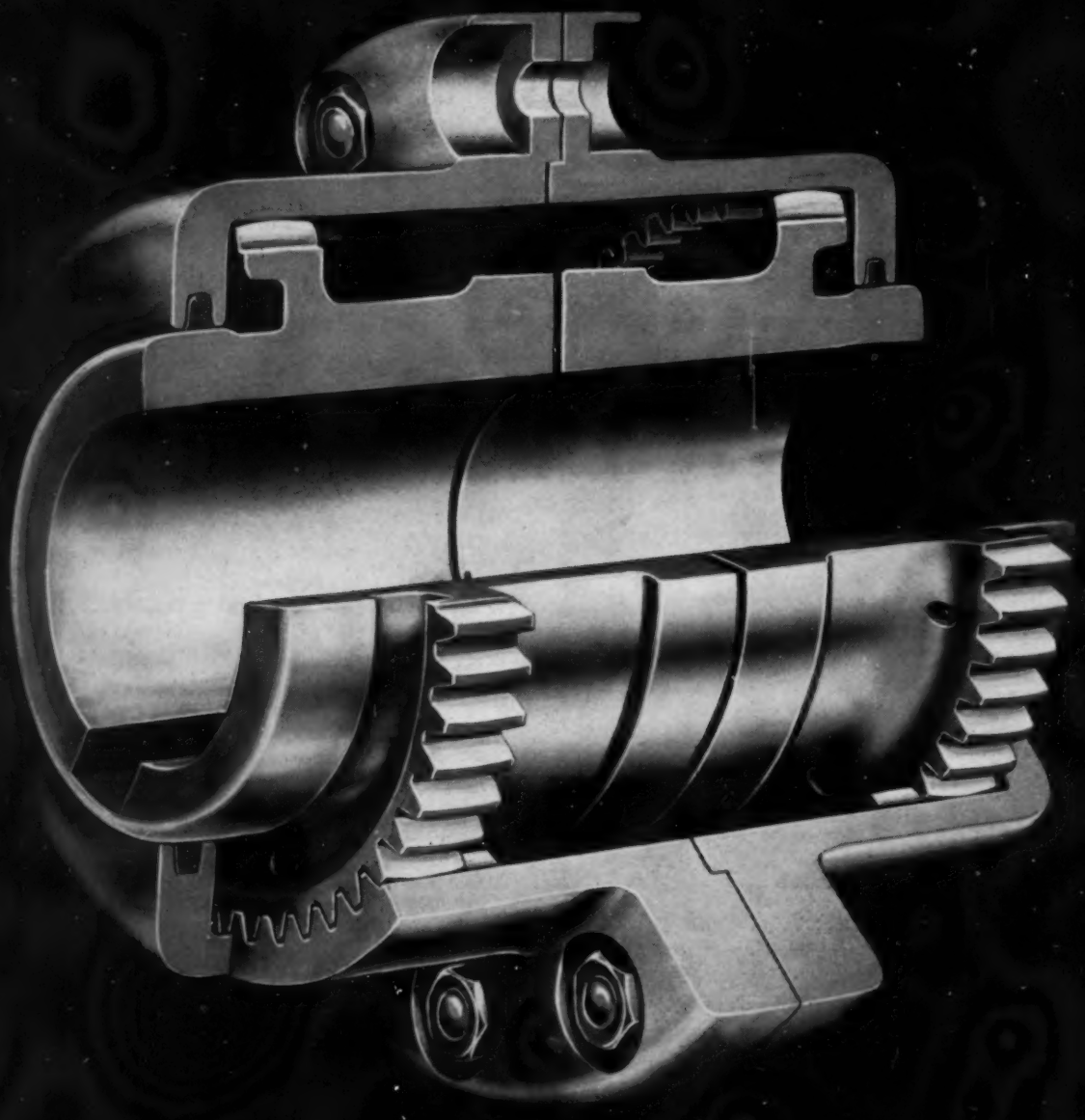

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